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FASCODE -- FAST ATMOSPHERIC SIGNATURE CODE
(SPECTRAL TRANSMITTANCE AND RADIANCE)

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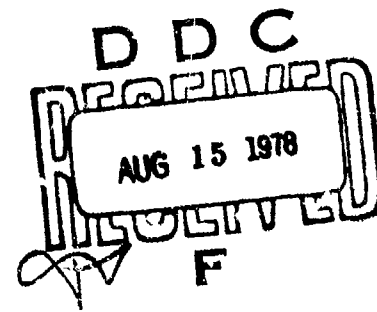
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1.0 INTRODUCTION

The problem of atmospheric transmission of infrared and visible radiation is of considerable interest from both a purely scientific and a practical point of view. The study of radiative transfer in an atmosphere involves a large number of physical and chemical effects and their proper theoretical treatment requires an increasing degree of mathematical sophistication. The vast amount of physical data necessary for a detailed description is typified by the AFGL line atlas which forms the core of the AFGL HITRAN Research Program^[1]. Uses of this data include laboratory studies of absorption, computing data for comparison or design of field observations of the atmosphere as well as such applications as the design of remote sensing or laser communication systems.

In the design and simulation of such systems, the atmospheric transmission in a given wave number interval can be a crucial consideration. For systems with relatively coarse spectral resolution, the detailed spectral structure of the absorption is not required. Thus, for such systems a high resolution technique for study and simulation may not be necessary and one may profitably use lower resolution codes such as the AFGL LOWTRAN Program^[2], but even in applied work a high degree of spectral resolution is increasingly in demand.

A number of line-by-line calculational methods have been reported which provide as detailed a spectral resolution as computationally possible. Among these may be found the LBL Program which has come to be known as the HITRAN Code^[1]. This method uses the AFGL line atlas and convolves all lines contributing to a given wave number to within a prescribed wave number range using a Lorentz line shape profile. The large number of calculations which the LBL Program performs requires a large amount of computer time which makes parametric studies as well as wide-band computations prohibitively expensive. Thus this code tends to be used for very necessary high resolution work and also as a tool to improve lower resolution models such as LOWTRAN.

With the growing demand for high resolution work, an effort was undertaken at AFGL to improve the efficiency of line-by-line calculations. The initial phase of this work resulted in the development of the HIRACC

algorithm for the convolution of Lorentz line shapes within 48 half-widths of a given wave number for a constant atmospheric temperature, density and composition. This extremely efficient algorithm resulted in a decreased running time of somewhat more than an order of magnitude as compared to the corresponding parts of the LBL Code. The HIRACC algorithm has been fully documented in an earlier report^[3] and we shall assume in the current report that the reader is familiar with Reference [3].

At this point it would be helpful to the reader to summarize the main features of the HIRACC algorithm which combine to give effectively an order of magnitude decrease in computational time. The first step in the development of HIRACC involved the decomposition of the line shape profile into three sub-profiles with different spectral widths. The algorithm was developed for a pure Lorentz line shape and the line shape profile was cut off beyond 48 half-widths from the line center. FASCODE (Fast Atmospheric Signature Code), however, was designed to use a Voigt profile. In order to accomplish this it was found convenient to extend the cut-off of the profiles to 64 half-widths. This enabled the definition of only one new sub-profile, a Gaussian function representing the Doppler contribution out to 4 half-widths. Note that beyond this number of half-widths the Doppler broadening may be neglected. The Voigt profile is then approximated by an appropriate combination of four functions. Figures 1.1 and 1.2 illustrate the resulting decomposition.

This decomposition has the advantage that the rapid variation of the profile near the line center can be represented properly by a specified sampling interval and the more slowly varying portion as one approaches the wings of the line can be properly represented with a larger increment between the points. In addition, the results of the four separate convolutions are not put together until the contributions from all the lines in the region are complete. An interpolation scheme was developed to compute those values required between the numerical values. Details are given in Section 2.

Another important result of Reference [3] was the determination of a criterion for the optimum sampling interval. A sampling interval which gives results to ~ 0.1 percent was shown to be given by

$$\Delta\nu \approx \alpha/4 \quad (1.1)$$

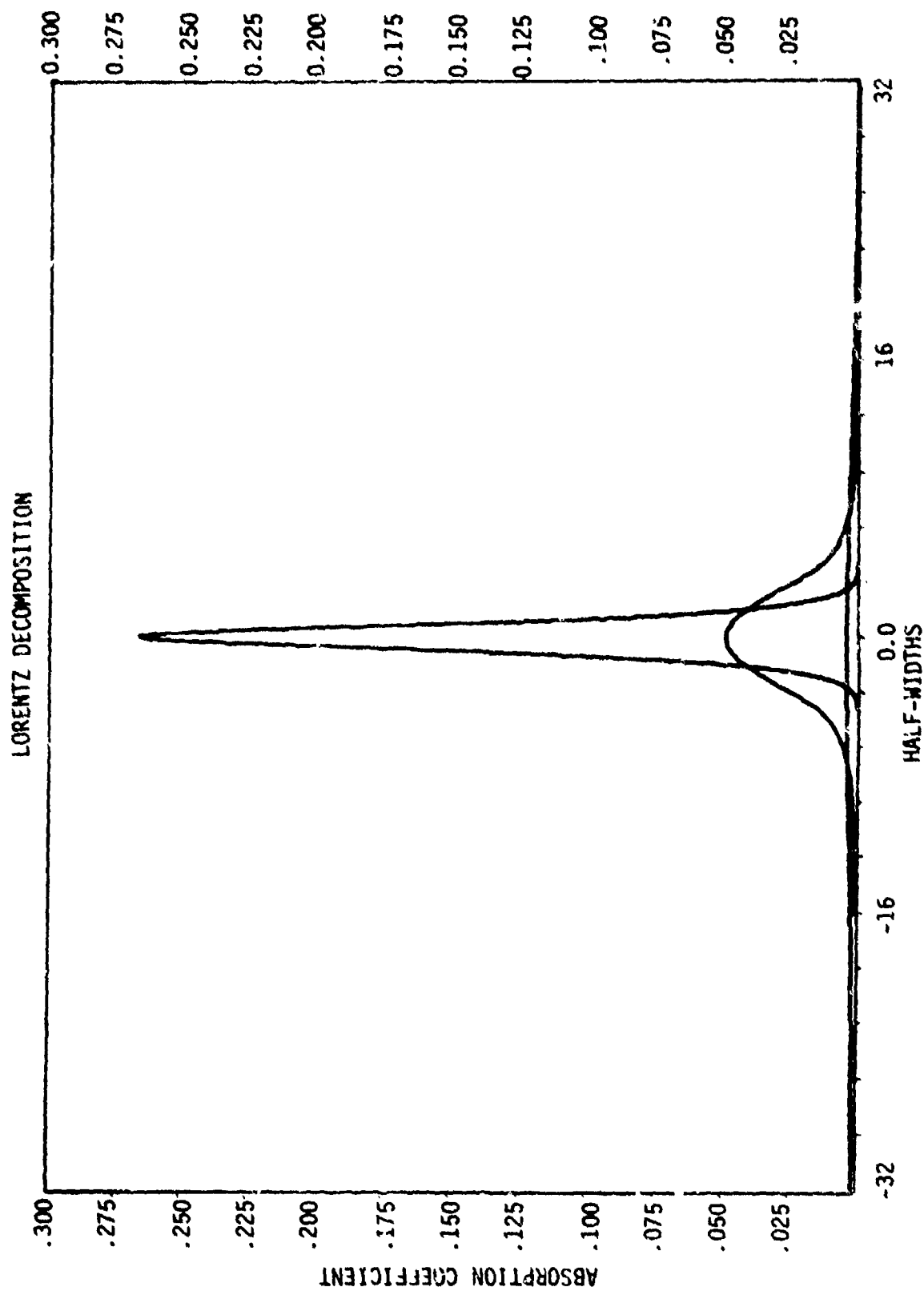


Figure 1.1: Decomposition of the Lorentz Function into Three Domains: -4 to 4 Half-Widths, -16 to 16 Half-Widths and -54 to 64 Half-Widths. The Sum of The Three Functions Gives $L(z) = (1/\pi)(1/1 + z^2)$. Only values to ± 32 half-widths are shown in the figure.

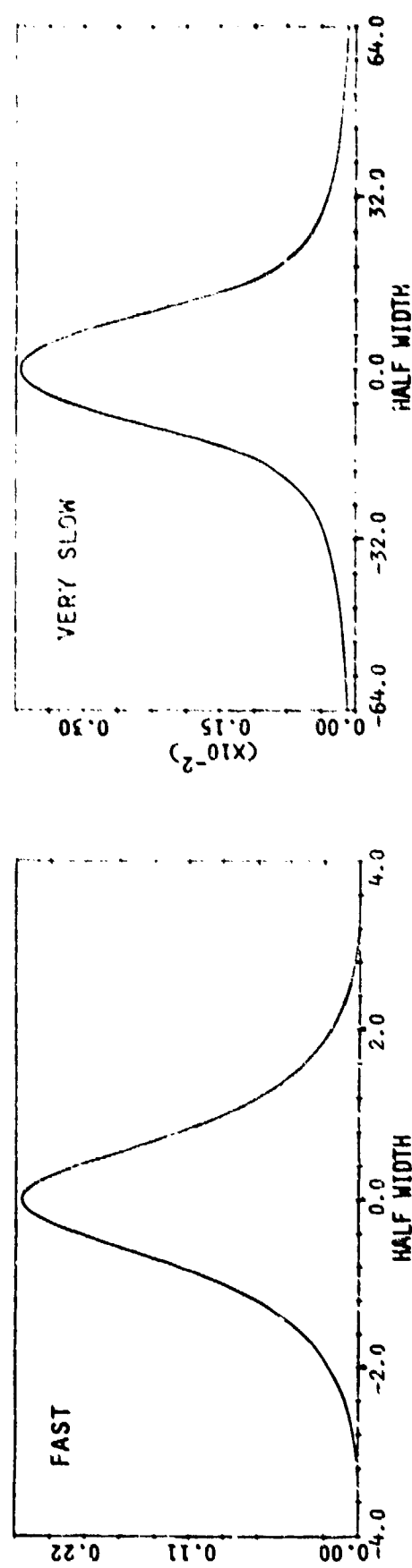
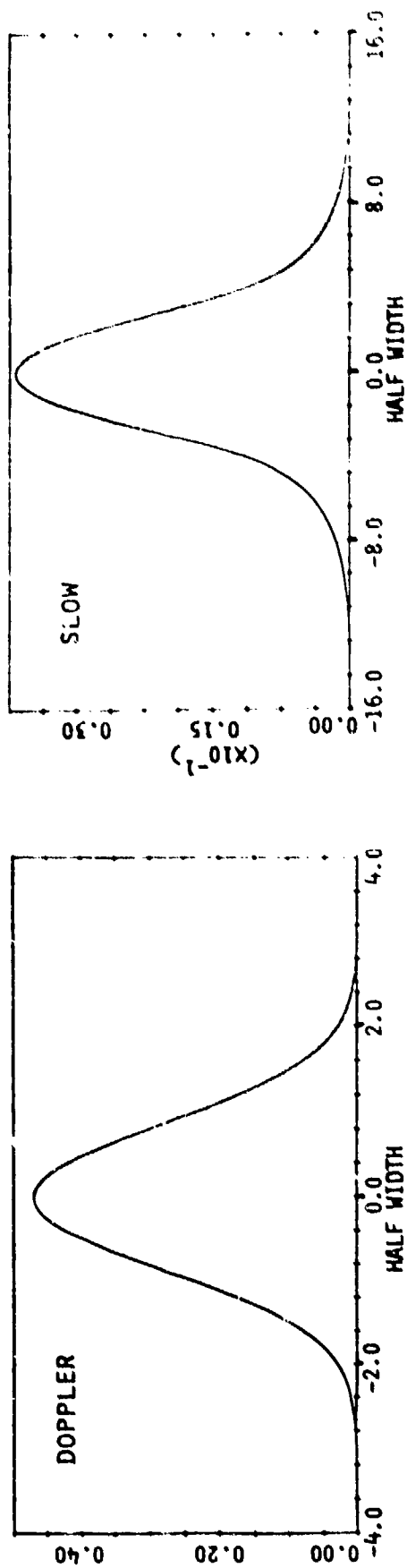


Figure 1.2: Four functions used to reconstruct the Voigt function.

where α is the average half-width of a line over the region of interest. It was also shown that the gain G obtained by the decomposition method over computing the entire line shape at a given sampling interval is given by the relation

$$G = N_{TOT} / \left[\sum_{m=1}^M N_M (\delta x_1 / \delta x_m) \right] \quad (1.2)$$

In this expression, N_{TOT} is the total number of half-widths over which the profile is required, N_m is the number of half-widths spanned by the m^{th} decomposed function and $(\delta x_1 / \delta x_m)$ is the ratio of the sampling interval for the first function to that required for the m^{th} function. For the decomposition utilized in this report, this yields a theoretical gain of 5 1/3.

We also point out another feature, namely that for a given spectral interval $(\nu_1 - \nu_2)$ which contains N lines, the same number of operations per line are performed for the sampling interval chosen according to the criterion. This implies that the convolution of a spectral absorptance for a given spectral interval will always take the same amount of computational time per line for high altitude layers where the lines are narrow as it does for lower layers where the lines may be broadened considerably. This feature is borne out by our results.

The HIRACC algorithm has been used to develop a multilayer transmission and radiance code which has been called FASCODE standing for Fast Atmospheric Signature Code. In the course of producing this code the basic HIRACC algorithm has been left intact, but several peripheral modifications have been implemented. In order to provide the capability of calculating at higher altitudes where the Lorentz profile is no longer appropriate, a Voigt line shape version has been developed with the additional feature that calculations are performed out to 64 half-widths. One of the great advantages of the HIRACC technique is that the line profile may be changed readily with only a small change in running time. The Voigt line shape profile is described in Section 2 of this report. We note in passing that purely Lorentz or purely Doppler versions of FASCODE may easily be implemented for the user whose application is in these domains. We emphasize, however, that no real penalty in running time will be paid by a user who exercises the Voigt version in either

of these altitude domains.

As mentioned above, the HIRACC algorithm for absorption was developed for a uniform atmospheric path (temperature, pressure and absorber concentration). The application of this method to the real atmosphere was made by approximating the real atmosphere by a series of layers with constant parameters in each layer. The results for each layer are then merged with the absorption coefficient obtained up to that layer. The merging algorithms are described in detail in Section 3 of this report.

Assuming local thermodynamic equilibrium, the absorption of radiation by a given volume of gas implies the re-emission of an equal amount of energy. Using this idea one may "invert" a transmission calculation to obtain the radiance from the gas along the given path. This type of calculation has been provided as an option in FASCODE to enable the user to calculate the radiance due to the atmosphere itself. For the user who has a boundary at one end of his path, a provision has been made to allow the user to add his own surface radiance model. Currently this takes the form of a black body radiating at a given temperature at the low end of a path starting in space and looking down. This could be easily modified if a different spectral radiance is required. This part of FASCODE is described in Section 4.

In Section 5, we present some avenues for future efforts and summarize the status of this effort. A series of appendices gives an overview of the FASCODE structure as well as complete documentation of the new routines involved. One of these appendices provides a User's Manual for some sample inputs and outputs.

2.0 LINE SHAPE — VOIGT PROFILE

To calculate spectral absorption contours for the types of absorbing paths encountered in the atmosphere, extensive consideration must be given to the spectral line shape. For atmospheric paths at lower altitudes, the spectral line shape within $\sim 5 \text{ cm}^{-1}$ of the line center is given satisfactorily by the pressure broadened (Lorentz) shape. Beyond $\sim 5 \text{ cm}^{-1}$ it has been shown that the shape is dependent on molecular type as has been discussed by Burch^[4], Winters et al^[5] and Clough et al^[3]. At high altitudes (low pressure) the line shape is due to thermal motion resulting in the Doppler line profile. The altitude above which the Doppler shape is valid is dependent on the wave number of the transition, the temperature and the molecular species. Between the domains for which the Lorentz shape and the Doppler shape are valid, the Voigt line shape must be utilized. Although the Voigt profile was originally derived for the case where broadening was due to natural broadening and thermal motion broadening, it is applicable in the present situation, since the shape function is the same for natural as for pressure broadening. This development uses an approximate method for the Voigt profile that is sufficiently accurate for most atmospheric problems and requires substantially reduced computer time compared to previously described methods.

The absorption coefficient for a pressure broadened line, $A_L(\nu)$, as a function of the wave number value of the radiation field, ν , the transition wave number, ν_0 , intensity S and half-width, α_L , (half-width at half maximum: HWHM) is given by the Lorentz function,

$$A_L(\nu) = \frac{S}{\pi} \frac{\alpha_L}{\alpha_L^2 + (\nu - \nu_0)^2} \quad (2.1)$$

The pressure broadened half-width, α_L , is a function of the absorbing and broadening molecule types and the vibrational-rotational states involved in the transition. The theory that has proven useful for calculating pressure broadened half-widths is due to Anderson^[6], as implemented by Tsao and Curnutte^[7]. The variation of the half-width with temperature

and pressure is given by the relationship

$$\alpha_L (P, T) = \alpha_L (P_0, T_0) \left(\frac{P}{P_0} \right) \left(\frac{T_0}{T} \right)^{\chi_T} \quad (2.2)$$

The half-widths on the AFGL line compilation are for $P_0 = 1$ atm, $T_0 = 296^\circ\text{K}$ and are typically of the order of $0.08 \text{ cm}^{-1}/\text{atm}$. The simplest theoretical result for the temperature dependence of the half-width gives $\chi_T = 0.5$. Recent calculations and experiments indicate that a higher value of χ_T is more appropriate, $\chi_T \approx 0.75$ (Benedict)^[8]. The absorption coefficient for a line broadened by thermal motion is given by the Gaussian function in terms of the Doppler width, α_D , (HWHM) as

$$A_D(\nu) = \sqrt{\frac{\ln 2}{\pi}} \frac{S}{\alpha_D} \exp \left[- (\ln 2) \left(\frac{\nu - \nu_0}{\alpha_D} \right)^2 \right] \quad (2.3)$$

where

$$\alpha_D = \frac{\nu_0}{c} \left(\frac{2 \ln 2 k T}{M/N_0} \right)^{1/2} \quad (2.4)$$

For the half-width, α_D , to be given in cm^{-1} at temperature $T(^{\circ}\text{K})$, c is the velocity of light in cm/sec , k is the Boltzmann factor in erg/deg , N_0 is Avogadro's number, and M is the molecular weight of the molecule type in gr .

Both functions have been defined such that the functional value at one half-width from the line center is one-half the function value at the line center, that is

$$\frac{A(\nu_0 \pm \alpha)}{A(\nu_0)} = \frac{1}{2} \quad (2.5)$$

It is also important that the integral of both functions yields the line strength, that is

$$S = \int_{-\infty}^{\infty} A(\nu) d\nu \quad (2.6)$$

For the purposes of this development, and in order to utilize the algorithm developed by Clough et al^[3], it will be useful to define a dimensionless argument for the line profiles,

$$z = \frac{\nu - \nu_0}{\alpha} \quad (2.7)$$

so that the Lorentz profile is given by

$$A_L(z) = \frac{1}{\pi} \frac{S}{\alpha_L} \frac{1}{1+z^2} \quad \text{with } z \equiv \frac{\nu - \nu_0}{\alpha_L} \quad (2.8)$$

and the Doppler profile is given by

$$A_D(z) = \sqrt{\frac{\ln 2}{\pi}} \frac{S}{\alpha_D} \exp \left[-(\ln 2) z^2 \right] \quad \text{with } z \equiv \frac{\nu - \nu_0}{\alpha_D} \quad (2.9)$$

The integral and half-width properties take on the following form

$$S = \int_{-\infty}^{\infty} A(z) \alpha dz \quad (2.10)$$

and

$$\frac{A\left(z = \frac{1}{2}\right)}{A(z = 0)} = \frac{1}{2} \quad (2.11)$$

Several excellent programs have been written to calculate the Voigt line profile which may be regarded as the convolution of the Lorentz function

with the Gaussian function (J.H. Pierluissi, P.C. Vanderwood and R.B. Gomez^[9]; S.R. Drayson^[10] and B.H. Armstrong^[11]). For the application of performing line-by-line calculations for a multi-layered atmosphere involving large numbers of spectral lines, these methods require a prohibitive amount of computational time and provide more accuracy than is generally required for such problems. Approximations for the computation of the Voigt profile have been suggested by Whiting^[12] and Kielkopf^[13]. The method described in the latter two papers involves approximating the Voigt function by a weighted sum of the Doppler and Lorentz functions. It is an extension of this approach that we have utilized in this development.

The startingpoint for our approximation to the Voigt function is the definition of a Voigt parameter that is simply calculable and is well behaved in the Lorentz and Doppler limits. For a spectral transition with a Doppler width, α_D , and a Lorentz width, α_L , we define a Voigt parameter, ζ , where

$$\zeta = \frac{\alpha_L}{\alpha_L + \alpha_D} \quad (2.12)$$

In the Lorentz and Doppler limits respectively we have,

$$\zeta = 0 \quad \alpha_L \ll \alpha_D \quad (\text{Doppler Limit}) \quad (2.13)$$

and

$$\zeta = 1 \quad \alpha_L \gg \alpha_D \quad (\text{Lorentz Limit}) \quad (2.14)$$

The definition of a Voigt half-width, α_V , is now required to proceed with our program. This definition is made consistent with the definition of the half-width for the Doppler and Lorentz functions; it is the half-width at half maximum of the Voigt function. An excellent approximation has been given by Kielkopf in terms of the Lorentz and Doppler widths,

$$\alpha_V = \frac{\alpha_L}{2} (1 + \epsilon) + \left[\frac{\alpha_L^2 (1 - \epsilon)^2}{4} + \alpha_D^2 \right]^{1/2} \quad (2.15)$$

with $\epsilon = 0.0990 \ln 2$.

In order to utilize this expression in terms of ζ , it is necessary to consider the determination of α_V in two domains of ζ :

$$\alpha_V = a_{VD}(\zeta) \cdot \alpha_D \quad 0.0 \leq \zeta \leq 0.5 \quad (\text{Doppler Regime}) \quad (2.16)$$

and

$$\alpha_V = a_{VL}(\zeta) \cdot \alpha_L \quad 0.5 \leq \zeta \leq 1.0 \quad (\text{Lorentz Regime}) \quad (2.17)$$

The quantities, $a_{VD}(\zeta)$, and $a_{VL}(\zeta)$, may be obtained from Equation (2.15) in terms of ζ as

$$a_{VD}(\zeta) = \frac{\alpha_V}{\alpha_D} = \left(\frac{1 + \epsilon}{2} \right) \left(\frac{\zeta}{1 - \zeta} \right) + \left[\left(\frac{1 - \epsilon}{2} \right)^2 \left(\frac{\zeta}{1 - \zeta} \right)^2 + 1 \right]^{1/2} \quad (2.18)$$

$$0. \leq \zeta \leq 0.5$$

and

$$a_{VL}(\zeta) = \frac{\alpha_V}{\alpha_L} = \left(\frac{1 + \epsilon}{2} \right) + \left[\left(\frac{1 - \epsilon}{2} \right)^2 + \left(\frac{1 - \zeta}{\zeta} \right)^2 \right]^{1/2} \quad (2.19)$$

$$0.5 \leq \zeta \leq 1.0$$

The largest error in the determination of the Voigt half-width using Equation (2.15) is $\approx 0.02\%$. Values of a_{VD} with $0.0 \leq \zeta \leq 0.5$ and for $a_{VL}(\zeta)$ with $0.5 \leq \zeta \leq 1$, using Equations (2.18) and (2.19) are determined for equally spaced values of ζ separated by 0.005. Plots of a_{VD} and a_{VL} as a function ζ appear in Figure 2.1 and Figure 2.2 respectively. This error is not as great as that incurred in using values of a_{VD} and a_{VL} at discrete values of ζ for

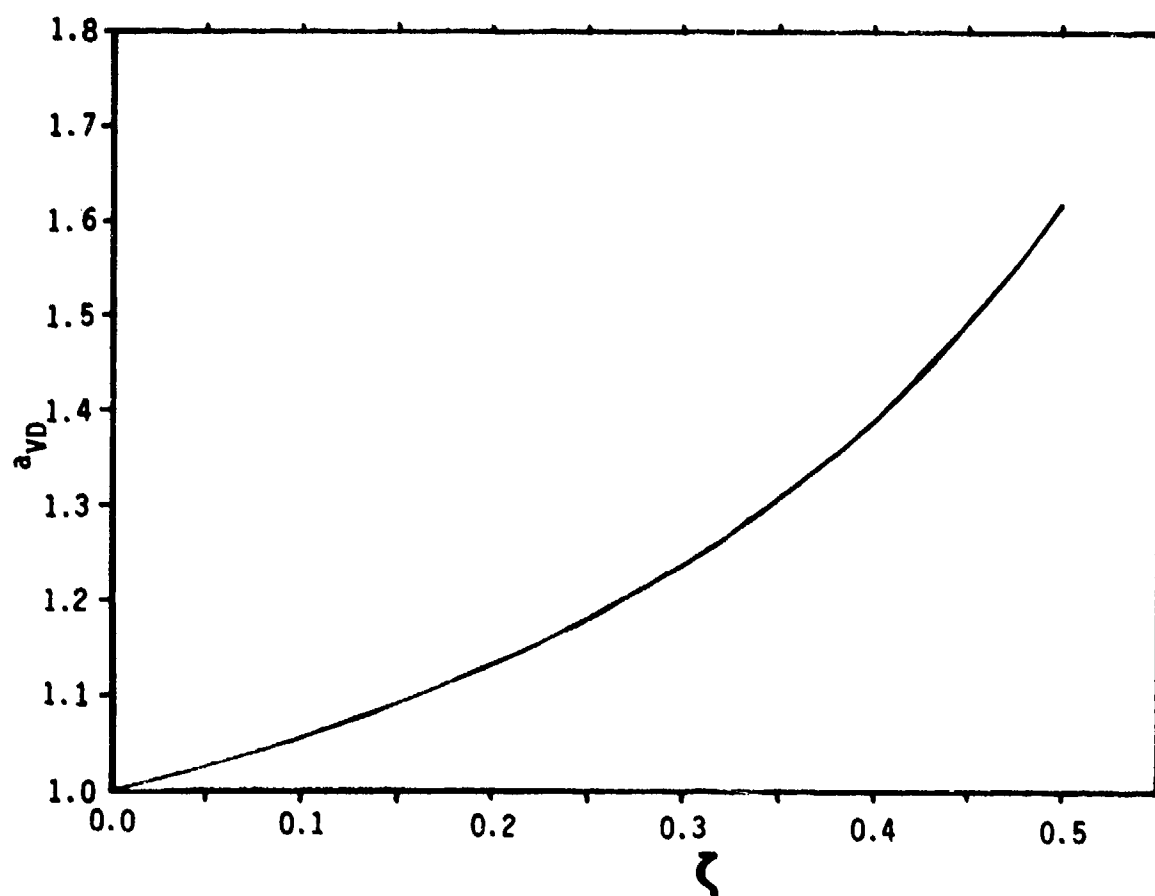


Figure 2.1: Plot of a_{VD} Vs. ζ ($0.0 \leq \zeta \leq 0.5$)

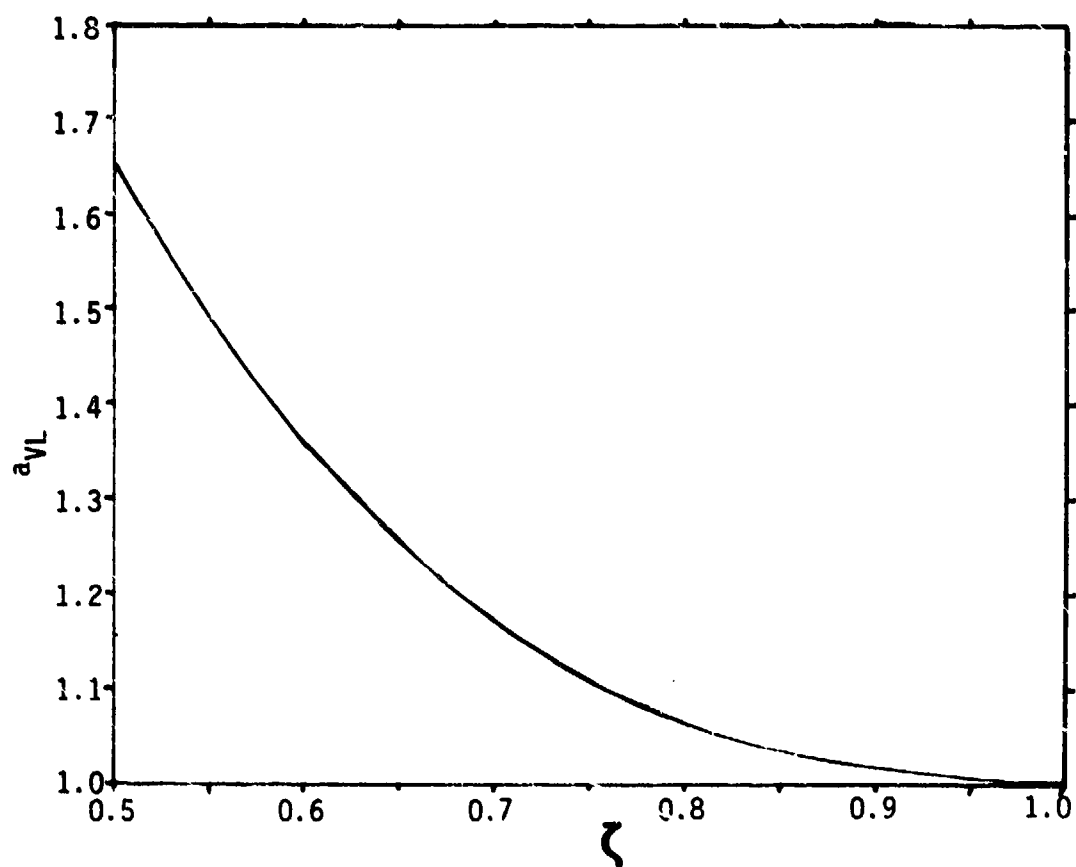


Figure 2.2: Plot of a_{VL} Vs. ζ ($0.5 \leq \zeta \leq 1.0$).

values of ζ intermediate to those tabulated. For most physical problems, the errors involved in the present method of determining α_V , are less than the errors in the values of α_D and α_L themselves. If it is desired to have more accurate values of α_{VD} and α_{VL} , the Voigt program of Armstrong can be utilized in an iterative procedure. In general, only one iteration is required to give a high degree of accuracy.

The Voigt function may now be approximated as a weighted sum of Doppler and Lorentz functions of width, α_V ,

$$A_V(\zeta, \alpha_V, Z) = (1 - C(\zeta)) A_D(\alpha_V, Z) + C(\zeta) A_L(\alpha_V, Z) \quad (2.20)$$

with $Z = (\nu - \nu_0)/\alpha_V$

This definition preserves the integral property desired: that the integral over Z gives back the line strength, S , since $C(\zeta)$ is independent of Z and the two functions, A_D and A_L , are themselves normalized to the line strength. Consider

$$\begin{aligned} \int_{-\infty}^{\infty} A_V(\zeta, \alpha_V, Z) dZ &= (1 - C(\zeta)) \int_{-\infty}^{\infty} A_D(\alpha_V, Z) \alpha_V dZ \\ &+ C(\zeta) \int_{-\infty}^{\infty} A_L(\alpha_V, Z) \alpha_V dZ, \end{aligned} \quad (2.21)$$

and

$$= (1 - C(\zeta)) S + C(\zeta) S \quad (2.22)$$

so that

$$= S \quad (2.23)$$

The remaining problem is the determination of the weighting constant, $C(\zeta)$.

In References [12] and [13] analytic functions have been given for

the constant $C(\zeta)$ as a function of Voigt parameter. The difficulty with the procedure outlined there is the large number of operations required to attain $C(\zeta)$ from the analytic expressions given. The most straightforward way to proceed is to determine the numerical function $C(\zeta)$ for the same 201 values of ζ used to determine the Voigt width. Rather than using the analytic expressions given in References [12] and [13] a least squares procedure has been used to determine $C(\zeta)$ by minimizing the weighted sum of the deviations squared, σ^2 , as obtained from Equation (2.20),

$$\sigma^2 = \sum_i W_i \left\{ C(\zeta) \left[A_L(\alpha_V, Z_i) - A_D(\alpha_V, Z_i) \right] - \left[A_V(\zeta, \alpha_V, Z_i) - A_D(\alpha_V, Z_i) \right] \right\}^2 \quad (2.24)$$

All the quantities have been defined except the weighting function W_i and the grid of points represented by Z_i . Some experience indicated that the weighting scheme which presented the best compromise between error in the central portion of the line profile and the line wing was obtained by setting the weight to the inverse of the Voigt value, that is

$$W_i = 1/A_V(\zeta, \alpha_V, Z_i) \quad (2.25)$$

A more obvious choice would have weighted the deviations inversely as the square of the Voigt value to maintain nearly constant percent error across the line profile. It was deemed more important to maintain a smaller percent error for the larger values of the function near the center of the line. The points were chosen at equally spaced intervals over three different domains for reasons that will be discussed later. The grid was chosen as follows:

$$\begin{aligned}
i = 1, 19 & \quad z_1 = 0, z_2 = 0.25, \dots, z_{19} = 4.0 \\
i = 20, 30 & \quad z_{20} = 5.0, z_{21} = 6.0, \dots, z_{30} = 16.0 \\
i = 31, 41 & \quad z_{31} = 20., z_{32} = 24., \dots, z_{41} = 64.0
\end{aligned}$$

The results obtained for the constant, $C(\zeta)$, are shown in Figure 2.3 as a function of ζ . The values are determined at the same 201 values of ζ in Figures 2.4 through 2.8. The continuous curves are the result of the Armstrong Voigt program and the x's are the values obtained from the least squares procedure. For $\zeta = 0$ and $\zeta = 1$ the Voigt function is exactly reproduced as a required result of the method. The results are given on a logarithmic plot in order to give perspective to the value of the function for which the percent errors are the largest. For $\zeta = 0.05$ to $\zeta = 0.3$, the percent error in the wing is of the order of 22 percent, but these errors occur for very small values of the function. Another region of moderate percent error is at $Z \approx 3$ half-widths for this same range of zeta. The largest percent error in this domain is $\sim 8\%$ for zeta ≈ 0.2 .

As indicated earlier, these results are sufficiently accurate for most atmospheric applications. As suggested by both Whiting^[12] and Kielkopf^[13], an error function can be added to reduce this remaining discrepancy to negligible proportions. Some discussion of this will appear in a subsequent section.

The method for approximating the Voigt profile has been developed and this development must now be incorporated into the algorithm for computing spectral absorption coefficients outlined by Clough et al^[3]. The Voigt function has been obtained as a weighted sum of the Doppler function and the Lorentz function. For purposes of convolving the approximate Voigt profile with the spectral line data, we consider Equations (2.8) and (2.9). In Reference [3] the slow convergence of $A_L(z)$ has been discussed and a method was developed to reduce computational effort for performing the convolution. Fortunately, the Doppler shape has very rapid convergence to zero as a function of the argument, z . The domain of the argument, z , for which values of the function $A_0(z)$ need to be considered are limited to $|z|$ less

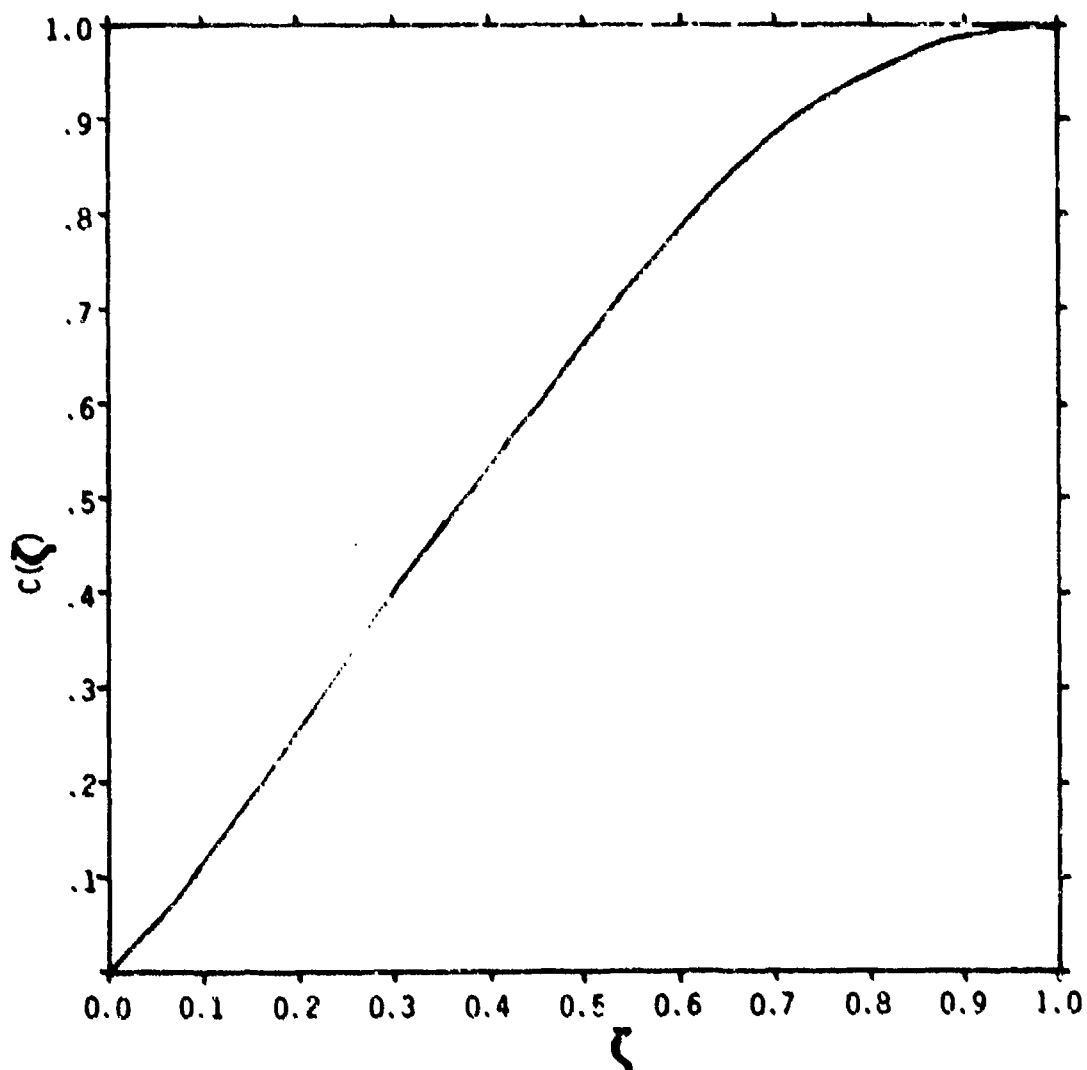


Figure 2.3: Plot of Least Squares Fit Parameter, $C(\zeta)$ Vs. ζ .

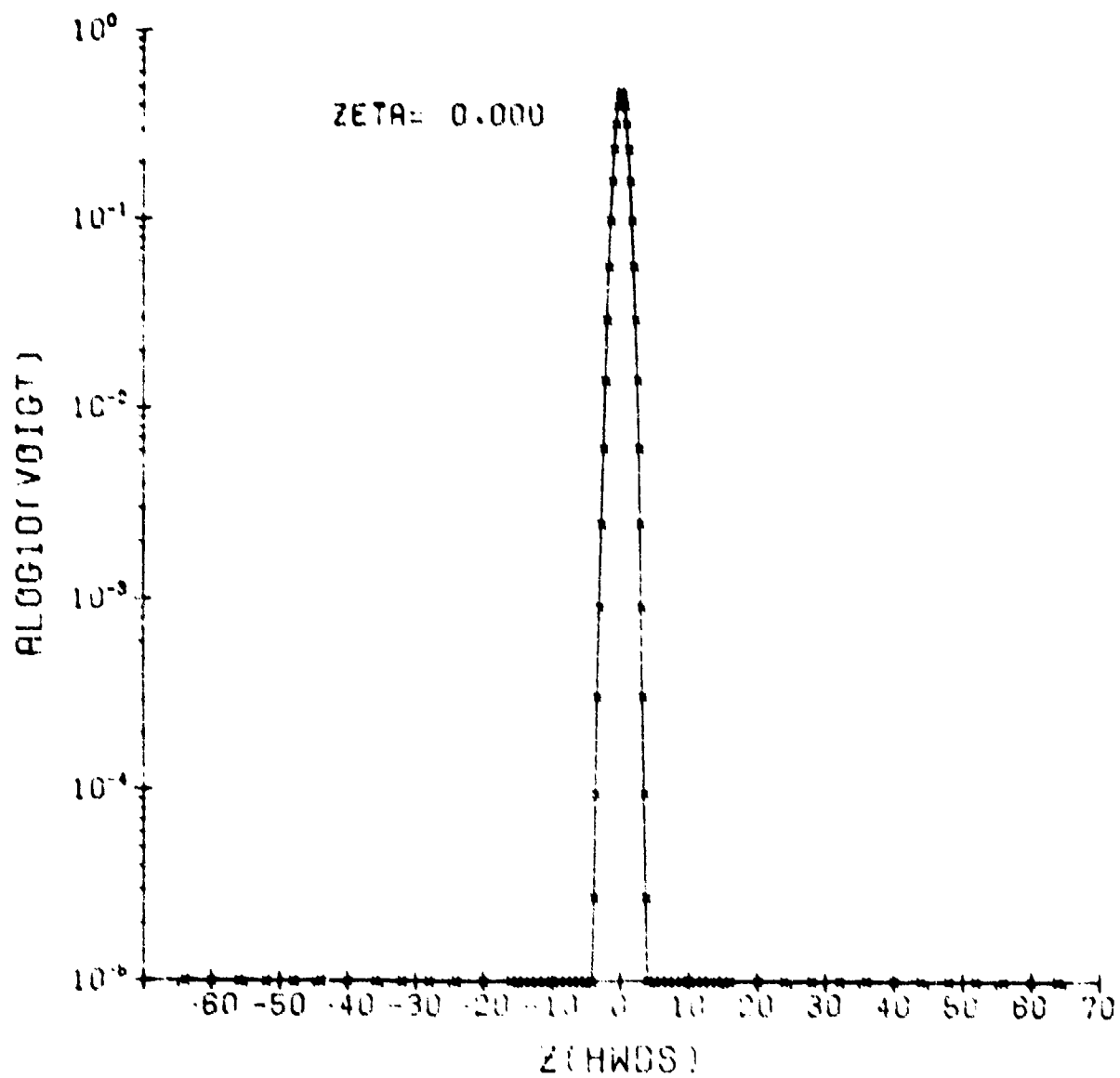


Figure 2.4: Voigt Line Shape Profile for $\zeta = 0$.

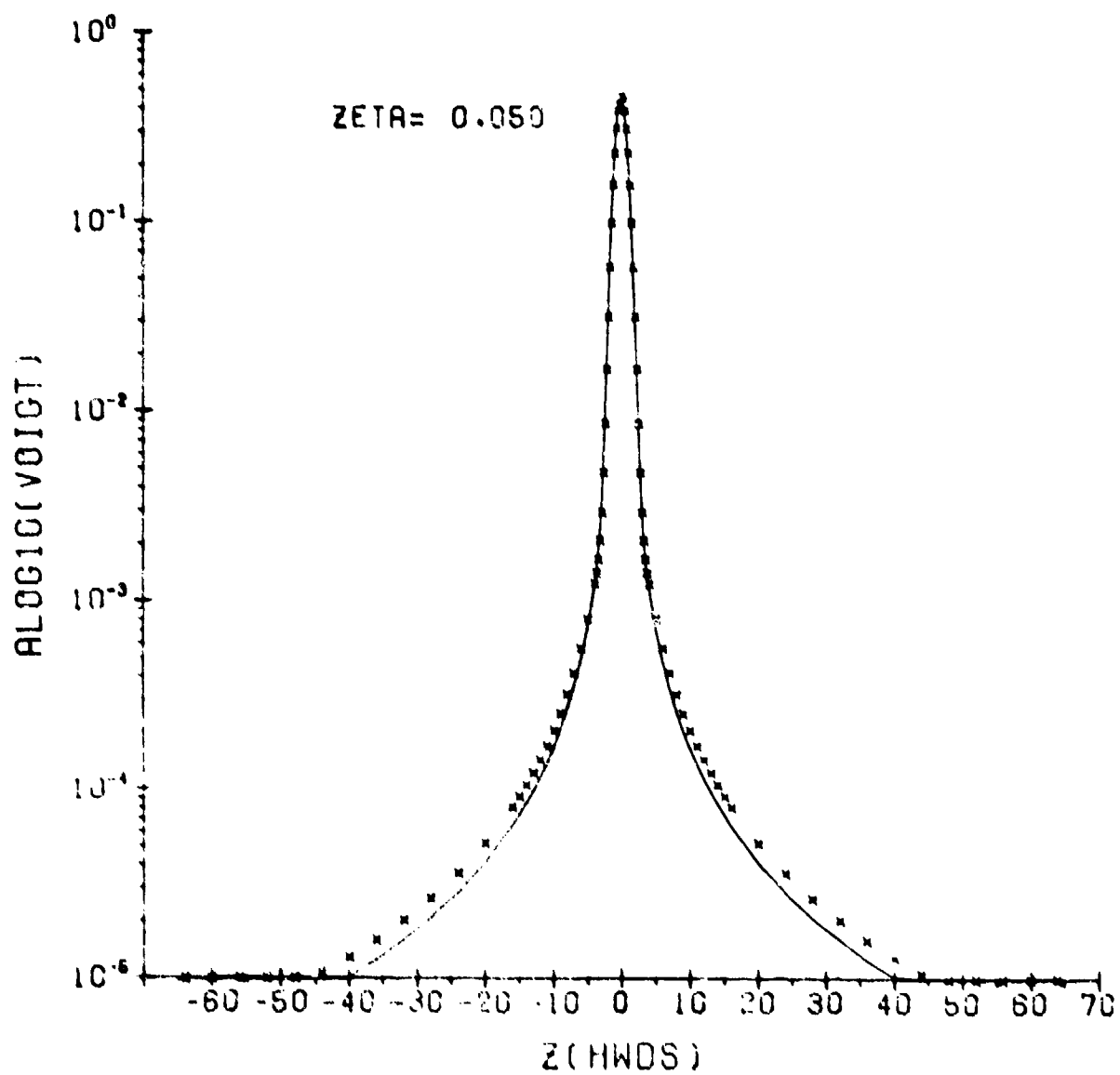


Figure 2.5: Voigt Line Shape profile for $\zeta = 0.050$

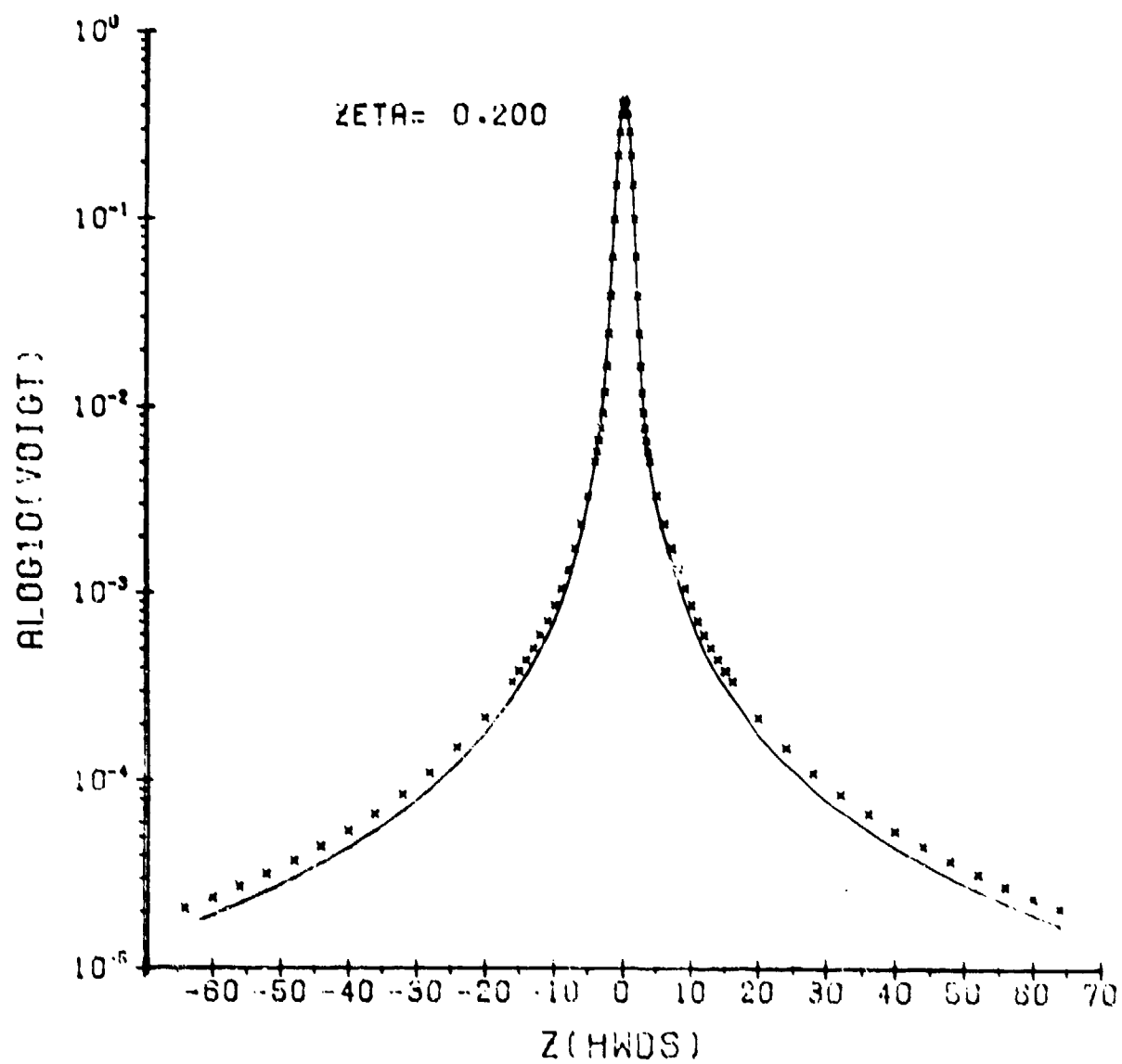


Figure 2.6: Voigt Line Shape Profile for $\zeta = 0.200$.

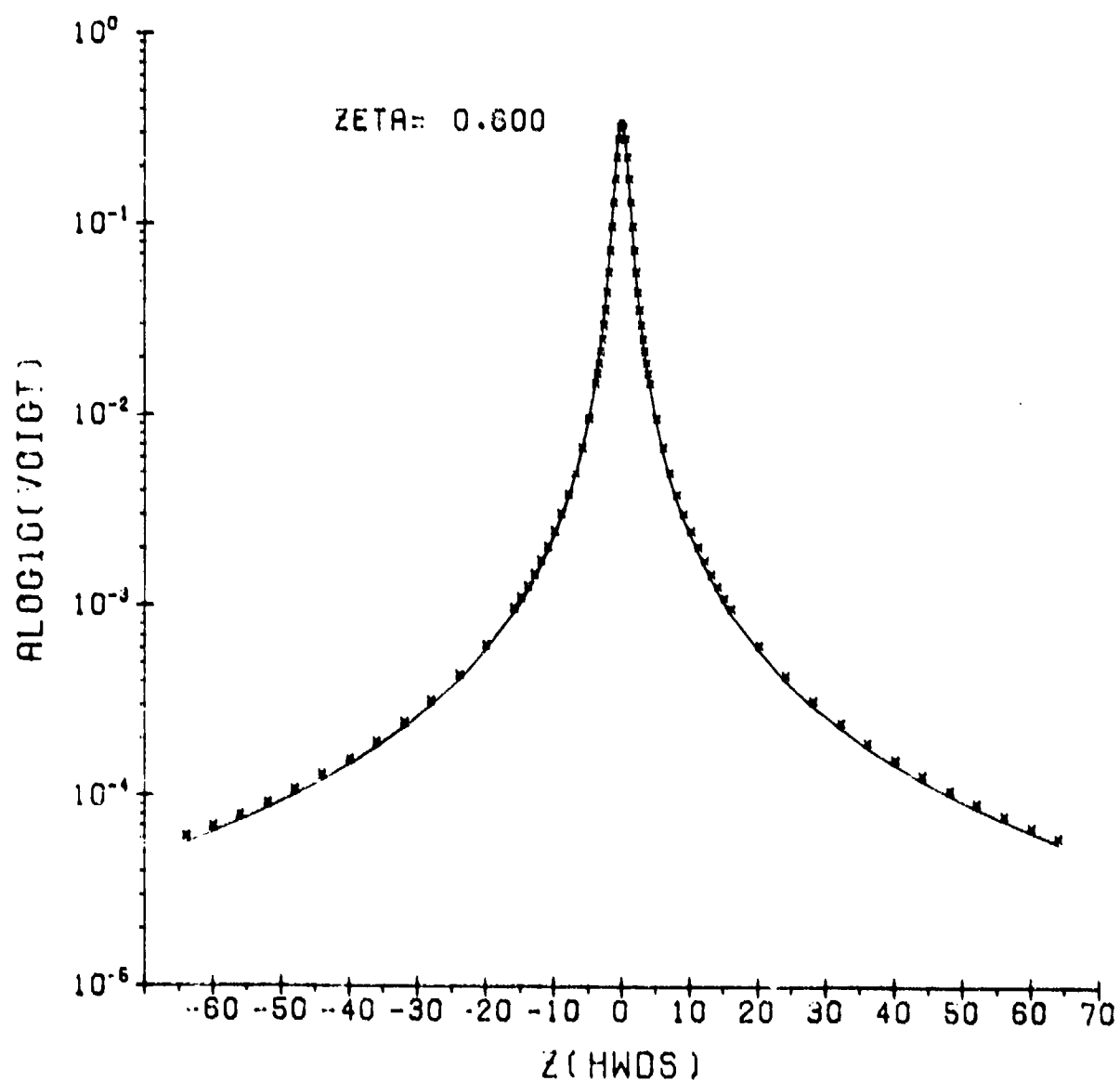


Figure 2.7: Voigt Line Shape Profile for $\zeta = 0.600$.

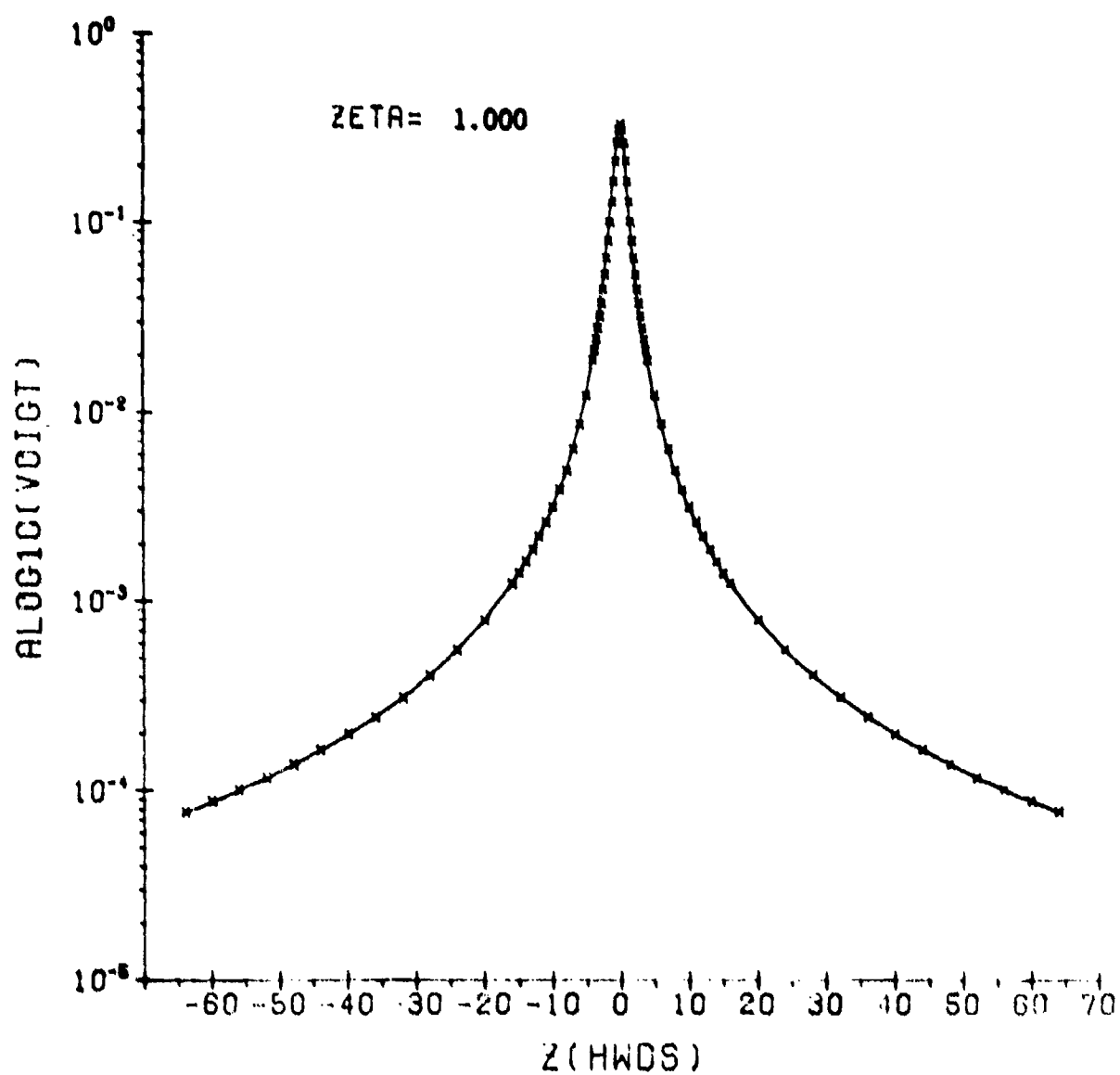


Figure 2.8: Voigt Line Shape Profile for $\zeta = 1.000$.

than four ($|z| \leq 4$), noting that $A_D(z = 4) = 7.7 \times 10^{-6}$. The normalized function for the Doppler line profile is given by

$$G(z) = \sqrt{\frac{\ln 2}{\pi}} \exp \left[- (\ln 2) z^2 \right] \quad (2.27)$$

It then is appropriate to decompose the Lorentz function $A_L(z)$ into three domains of z ,

$$0 \leq z \leq 4$$

$$0 \leq z \leq 16$$

and

$$0 \leq z \leq 64 \quad (2.28)$$

This decomposition is performed in a manner similar to that described in Reference [3]. A quartic function is defined over the domain $0 \leq z \leq 4$ where

$$Q_1 = \frac{1}{\pi} (a_1 + b_1 z^2 + c_1 z^4) \quad (2.29)$$

The normalized Lorentz function, L , is

$$L = \frac{1}{\pi} \frac{1}{1 + z^2} \quad (2.30)$$

The coefficients of the quartic are chosen such that for the function $(L - Q_1)$, the value and the first and the second derivative are zero at the boundary, Z_b . For the first function, $Z_b = Z_1 = 4$. These constraints are achieved by the following relations

$$a_1 = (1 + 3 Z_b^2 + 3 Z_b^4) / (1 + Z_b^2) \quad (2.31)$$

$$b_1 = - (1 + 3 Z_b^2) / (1 + Z_b^2)^3 \quad (2.32)$$

and

$$c_1 = 1/(1 + z_b^2)^3 \quad (2.33)$$

Similarly, a second quartic function, Q_2 , is defined such that for function $(L - Q_2)$, the value, the first and second derivative are zero at the boundary $Z_b = Z_2$. In this case $Z_b = Z_2 = 16$. In the region from $16 \leq |Z| \leq 64$ the function utilized is the Lorentz function itself. The procedure is more obvious in tabular form:

Function	DOMAIN		
	$0 \leq Z \leq 4$	$0 \leq Z \leq 16$	$0 \leq Z \leq 64$
	(Doppler)		
$X_D(z)$	$G(z)$	0	0
	(Lorentz)		
$X_{L1}(z)$	$L(z) - Q_1(z)$	0	0
$X_{L2}(z)$	$Q_1(z) - Q_2(z)$	$L(z) - Q_2(z)$	0
$X_{L3}(z)$	$Q_2(z)$	$Q_2(z)$	$L(z)$

Note that the Doppler function spans the same domain as the first decomposed Lorentz function, that the functions X_{Li} sum to $L(z)$ in each domain and that the functions are continuous across the domain boundaries.

The four functions that will be utilized to reconstruct the Voigt function are shown in Figure 1.2. The functions are tabulated at 201 values of the argument $|z|$ over the domain valid for each function.

The total expression for approximating the absorption due to the Voigt profile is given by

$$A_V(\zeta, \alpha_V, z) = \frac{S}{\alpha_V} \left\{ (1 - C(\zeta)) X_D(z) + C(\zeta) [X_{L1}(z) + X_{L2}(z) + X_{L3}(z)] \right\} \quad (2.34)$$

This may be separated into three functions where

$$\begin{aligned} A_{V1}(\zeta, \alpha_V, z) &= \frac{S}{\alpha_V} \left\{ (1 - C(\zeta)) X_D(z) + C(\zeta) X_{L1}(z) \right\} \quad 0 \leq |z| \leq 4, \\ A_{V2}(\zeta, \alpha_V, z) &= \frac{S}{\alpha_V} C(\zeta) X_{L2}(z) \quad 0 \leq |z| \leq 16, \\ A_{V3}(\zeta, \alpha_V, z) &= \frac{S}{\alpha_V} C(\zeta) X_{L3}(z) \quad 0 \leq |z| \leq 64. \end{aligned} \quad (2.35)$$

The sampling interval established in Reference [3] indicates that A_{V1} is sampled at intervals of $\frac{\alpha_V}{4}$, A_{V2} at intervals α_V , and A_{V3} at intervals of $4 \cdot \alpha_V$. This sampling scheme results in each function being sampled at 33 values. The results of the convolutions over the three domains are stored in arrays FF, SF and VSF. The saving in computational effort results from two principal reasons. Only 99 values are required to describe the Voigt function over ± 64 half-widths. The composite spectrum from the three arrays (FF, SF, and VSF) is constructed only after the convolutions have been completed for all the lines in a given spectral interval. This latter point is one that was not sufficiently stressed in Reference [3]. The implication of this technique is that not only is the grid of the function fine in the region where the function is varying rapidly and coarse in the region where the function is varying slowly (actually there are three discrete sampling intervals), but that the values for intermediate points are not calculated until after the contributions from all the spectral lines have

been determined. This is achieved by interpolating the VSF array into the SF array, and the SF array into the FF array yielding the final results.

3.0 TRANSMISSION THROUGH THE REAL LAYERED ATMOSPHERE

The HIRACC algorithm^[3] as originally reported by Clough et al computed absorption coefficients for a given path through a gas. The thermodynamic properties over this path were assumed to be constant which enabled the definition of a constant sampling interval over the spectral region of interest. The path itself was defined through input in the form of column densities of the appropriate molecular absorbers together with the temperature and pressure. We note that column densities are the required units for the AFGL tape.

At first glance, it might appear that calculations of the spectral absorptance (or optical depth) in the real atmosphere would require only the definition of the proper values of these column densities. However, one must take into account the variation of thermodynamic properties along the path as well as the fact that certain absorber molecules, such as H_2O and O_3 are not uniformly mixed at all altitudes. For example, ozone concentration peaks in the stratosphere. When a calculation of the optical depth at a higher altitude is required, one must take into account the fact that the decreased pressure implies a narrower line width. Indeed, as one goes from sea level toward space, the line shape profile passes from almost pure Lorentz to pure Doppler. If one uses an improper sampling interval to calculate the spectral absorptance, it is clear that important absorption features can easily be neglected, thus yielding incorrect results. Therefore a proper calculation of absorption over a path traversing a large region of the atmosphere will require an appropriate variation of the sampling interval with altitude. One could, of course, use the small sampling interval required at high altitude layers for all layers, but this would require unnecessary calculations at the lower altitudes.

In order to use the HIRACC algorithm with as little modification as possible, we have taken the approach discussed by McClatchey et al^[14] and approximated the real atmosphere by a series of layers, each defined to have constant pressure and temperature and appropriate values of the column densities of the absorbing molecules. Clearly such a decomposition is not unique and requires the user to exercise some care in defining the atmosphere as will be discussed below. While this arrangement may demand a certain degree of

sophistication of the user, it is judged that this solution will enable a user to be more flexible in changing from one program to another than he would be if the program were tied to a given atmospheric model.

The basic structure of FASCODE is then a successive application of the HIRACC algorithm for successive atmospheric layers with an appropriate merging of the results. For convenience, the HIRACC Program reported in Reference [3] has been left almost unchanged except to modify it to subroutine form and to include the Voigt line shape profile described in the previous section.

The merger of the absorptance for two different layers is performed in the following manner. The results for the first layer are computed and written to disk as described in Reference [3]. (We remind the reader that the HIRACC algorithm processes the spectral absorptance in "panels", namely in groups of data defined at wave numbers separated by a sampling interval. Typically there are 2400 quantities in a panel but a panel may be shorter at the end and beginning of the requested wave number interval.) The resolution at which the first layer is to be calculated is determined by the sampling interval criterion described by Clough et al^[3], namely one-quarter of the average half-width of the lines. The next layer to be computed may have pressure and temperature sufficiently different such that a new sampling interval is required by the sampling criterion. Let the sampling interval for the first layer be DV_1 and that for the second, DV_2 . In the initial development of FASCODE a decision was made to limit the program to specified ratios DV_1/DV_2 . Note that since the pressure in the atmosphere is a monotonically decreasing function of altitude, the average half-width of a Lorentz line profile will decrease as the calculation proceeds from lower to higher altitudes. Thus the sampling interval determined using the criterion of Reference [3] will also decrease as the calculation proceeds to the higher altitudes, until the pressure no longer remains the principal determining factor. This will occur at altitudes where the Doppler width becomes dominant in the determination of the half-widths. Such effects are already included in the Voigt line shape profile model discussed above. In addition, the Voigt model provides a proper treatment of the transition region at those altitudes where neither the Doppler nor the Lorentz profile is appropriate.

In general then, the sampling interval is larger at lower altitudes and smaller at the higher levels. This implies that a calculation which proceeds from the lower to the higher layers is more efficient since one would not have to perform the calculation of the lower layers at the small sampling intervals required by the narrower line shapes at the higher altitudes. Therefore, in FASCODE, the HIRACC algorithm is implemented by starting at the lowest layer (highest pressure) and proceeding to higher layers (lower pressures).

Since the decision was made to limit the number of ratios of the sampling intervals between two adjacent layers, FASCODE resets the DV of a new layer to the nearest allowed ratio. Note that the user must be careful to prepare the atmospheric input with a sufficient number of layers so that the criterion for the ratios is met. This is not a difficult condition to meet and it is discussed in detail in the User's Manual in Appendix B. In principle, the restriction to a fixed number of ratios is not necessary. This was discovered late in the development of FASCODE, but was left for future effort. We shall discuss this briefly in the final section.

The computation of the second layer then proceeds using the HIRACC algorithm with the reset value of the sampling interval. The new results are also written to disk, by Subroutine PANEL, using a different file name. Having obtained the spectral absorptance for each layer, one now needs a method to merge the two results such that after the merger one has the absorptance for a path through both layers defined at the resolution of the higher layer. This is obtained by interpolating the "old" or coarser resolution results into the "new" or finer resolution values of the spectral absorptance. A simple four-point Lagrangian interpolation scheme proved adequate^[15]. This is summarized as follows: If $f(x)$ is a function defined numerically over a given region with a constant increment h , then the value of the function at some point $(x_0 + ph)$, where p is a real number $(-1 < p < 2)$, is approximated by the relation

$$f(x_0 + ph) = A_{-1}f_{-1} + A_0f_0 + A_1f_1 + A_2f_2 \quad (3.1)$$

Here f_n is the value of the function at $(x_0 + ph)$ and the constants are given

by the relations

$$A_{-1} = -p(p - 1)(p - 2)/6 \quad (3.2)$$

$$A_0 = (p^2 - 1)(p - 2)/2 \quad (3.3)$$

$$A_1 = -p(p + 1)(p - 2)/2 \quad (3.4)$$

$$A_2 = p(p^2 - 1)/6 \quad (3.5)$$

The number of allowed resolution ratios was chosen in the following manner. First it was required that the old and new absorptances should be aligned at some running values of the wave number at least. This implied that the ratios were to be ratios of integers. For further simplification it was also required that the ratio be of the form $(N + 1)/N$. In addition, one must include the case where the sampling interval does not change, namely a one-to-one ratio. After some experimenting with larger values of the integer N , it was found adequate to limit the number of ratios to the following: 2/1, 3/2, 4/3, 5/4 and 1/1.

The interpolation is then performed by identifying the quantity x_0 in Equation (3.1) with the next lowest wave number of the old array below the value needed for addition to the new array. The interpolation is characterized by an index (called ITYPE in the program) which is the number of points needing interpolation between the wave numbers which co-align in the two arrays. This will be clear after a glance at Table 3.1. For the 1/1 case (straight add) no interpolation is required and the index is zero. For the 2/1 ratio, one point must be interpolated and ITYPE=1. The remaining schemes are quite clear. The value of the index ITYPE is used to determine the values of p in Equations (3.2) - (3.5) and then in turn to compute arrays of the interpolation constants A_i for interpolating the values between the co-aligned wave numbers. The remainder of the merging algorithm consists in bookkeeping to access the two disk files containing the panel data for the old and the new layers. In addition, the merged results are also written to a third disk file for merging with the next layer. The procedure is

TABLE 3.1. ALLOWED RATIOS AND SCHEMES

Ratio	Scheme		Index (ITYPE)
1/1	Old	•	0
	New	•	
2/1	Old	•	1
	New	•	
3/2	Old	•	2
	New	•	
4/3	Old	•	3
	New	•	
5/4	Old	•	4
	New	•	

• = Calculated spectra. value

x = Interpolated spectral value to match value in new spectrum

then continued until the final layer is processed.

In order to test the merging algorithm, the following procedure was devised. The calculation was performed as described above except that the spectral absorptance calculated for each layer was replaced by a known function of simple form. Consider the case where the absorptances from two layers are merged. If ν_0 is the lower boundary of the frequency range of interest and $\Delta\nu_1$ and $\Delta\nu_2$ are the sampling intervals for layers 1 and 2 respectively, ($\Delta\nu_1 \geq \Delta\nu_2$ by assumption) then the test is made by replacing the calculated optical depths in each layer (e.g., τ_1 and τ_2) by the expressions

$$\tau_1 = \nu_0 + (j_1 - 1) \Delta\nu_1/2 \text{ and } \tau_2 = \nu_0 + (j_2 - 1)\Delta\nu_2/2 \quad (3.6)$$

where j_1 and j_2 are running indices which give the number of frequencies at which calculations have been performed, i.e., the lower bound wave number is $j = 1$ and the upper bound is $j = n_\ell$ where n_ℓ is the total number of frequency values in the region calculated.

The array τ_1 is to be merged into the finer spaced array τ_2 . Call the merged result τ_{12} and let j be its running index. From Equation (3.6), it follows readily that

$$|\tau_{12}(j+1) - \tau_{12}(j)| = \Delta\nu_2 \quad (3.7)$$

provided the merging process is correct. Since the interpolation involved cannot be expected to be exact, the following test was made for all values of τ_2

$$|\tau_{12}(j) - \tau_{12}(j-1)|/\Delta\nu_2 \leq 10^{-4} \quad (3.8)$$

If this inequality was not satisfied the program was directed to print this fact together with the associated parameters.

This testing procedure was followed and the inequality (Equation (3.8)) was found to be satisfied at all points except at the lower and upper

bounds of the wave number interval. This was due to the problems of starting and stopping the Lagrangian interpolation when points are not available. A simplified interpolation scheme was chosen at these boundaries which did not have sufficient accuracy to satisfy the merging criterion in Equation (3.8). This is not a problem however, since the HIRACC algorithm^[3] automatically expands the requested wave number region by a small amount in order to assure that all lines which contribute to a wave number interval are included. Thus we conclude that the merging procedure does pass our criterion. The extension of this test to more than two layers is straightforward. In Equation (3.6), the factor $1/2$ is to be replaced by $1/N$ where N is the number of layers.

The next test of the algorithm required the calculation of a case for which another high-resolution calculation has been performed. For this purpose, the calculations done by Kyle at NCAR were selected^[16]. Kyle performed a multilayer atmospheric transmission calculation in the wave number region $(1-2600) \text{ cm}^{-1}$. He used the AFGL tape, a Voigt line shape truncated at 5 cm^{-1} from the line center and a model atmosphere based on the AFGL mid-latitude summer profile^[14]. The atmosphere he used is given in Table 3.2. We note briefly that Kyle's results were degraded in resolution by convolution with a triangular instrument scanning function with full width at half maximum of 20, 5, and 0.1 cm^{-1} . Since FASCODE did not as yet have this feature, we compared directly with his highest resolution graphs. It is also noted that Kyle's atmosphere had to be modified to fit the ratio criterion mentioned above. This was done by defining additional layers where there were larger altitude gaps in Kyle's atmosphere. We show the resulting atmospheric model in Table 3.3. We limited ourselves to the wave number range $(2000, 2200) \text{ cm}^{-1}$. This shall be referred to as the test problem.

The results of the calculation for our test problem are shown in Figure 4.2. The spectra obtained by FASCODE are in entire agreement with those obtained by Kyle. We delay further discussion of the results until the next section in order to present transmittance and radiance results at the same time.

TABLE 3.2. ATMOSPHERIC LAYERS USED IN THE COMPUTATIONS OF KYLE[16]

Layer	Alt. (km)	Pressure Range (mb)	Temp. (°K)	Number of Molecules in Layer (molecules/cm ²)							
				H ₂ O	CO ₂	O ₃	N ₂ O	CO	CH ₄	O ₂	
1	4	628.	152.	249	1.11x10 ²²	3.32x10 ²¹	1.60x10 ¹⁸	2.77x10 ¹⁸	7.55x10 ¹⁷	1.61x10 ¹⁹	2.11x10 ²⁴
2	14	152.	59.4	216	1.19x10 ¹⁸	6.47x10 ²⁰	1.90x10 ¹⁸	5.39x10 ¹⁷	1.47x10 ¹⁷	3.14x10 ¹⁸	4.12x10 ²³
3A*		59.4	13.2	223	1.87x10 ¹⁹	3.23x10 ²⁰	4.20x10 ¹⁸	2.69x10 ¹⁷	7.34x10 ¹⁶	1.56x10 ¹⁸	2.05x10 ²³
3B*	30	13.2	3.32	241	6.40x10 ¹⁸	6.91x10 ¹⁹	1.80x10 ¹⁸	5.76x10 ¹⁶	1.57x10 ¹⁶	3.35x10 ¹⁷	4.40x10 ²²
4	40	3.32	1.75	262	6.40x10 ¹⁷	1.10x10 ¹⁹	2.00x10 ¹⁷	9.15x10 ¹⁵	2.49x10 ¹⁵	5.32x10 ¹⁶	6.98x10 ²¹
5	45	1.75	0.58	275	3.70x10 ¹⁷	8.11x10 ¹⁸	6.70x10 ¹⁶	6.76x10 ¹⁵	1.84x10 ¹⁵	3.93x10 ¹⁶	5.16x10 ²¹
6	54	0.58	0.00	259	1.00x10 ¹⁷	4.08x10 ¹⁸	8.60x10 ¹⁵	3.39x10 ¹⁵	9.26x10 ¹⁴	1.98x10 ¹⁶	2.59x10 ²¹

*The 152-13.2 mb pressure range was too large for a single layer approximation, so an additional layer was added at 59.4 mb. This altitude is not included in the figures.

TABLE 3.3. ATMOSPHERIC LAYERS USED IN THE TEST PROBLEM

Layer	Pressure (mb)	Temp. (K)	Number of Molecules in Layer (molecules/cm ²)						
			H ₂ O	CO ₂	O ₃	N ₂ O	CO	CH ₄	O ₂
1	525.857	264.	.938E+22	.141E+22	.261E+18	.120E+19	.320E+18	.683E+19	.894E+24
2	332.874	243.	.165E+22	.128E+22	.459E+18	.109E+19	.292E+18	.622E+19	.815E+24
3	197.564	223.	.632E+20	.626E+21	.535E+18	.531E+18	.142E+18	.304E+19	.398E+24
4	124.000	216.	.761E+19	.404E+21	.785E+18	.343E+18	.919E+17	.196E+19	.257E+24
5	77.277	217.	.505E+19	.251E+21	.108E+19	.213E+18	.570E+17	.122E+19	.159E+24
6	36.603	224.	.135E+20	.328E+21	.331E+19	.279E+18	.746E+17	.159E+19	.209E+24
7	8.340	243.	.499E+19	.705E+20	.126E+19	.598E+17	.160E+17	.342E+18	.448E+23
8	2.551	263.	.491E+18	.112E+20	.153E+18	.948E+16	.254E+16	.542E+17	.710E+22
9	1.156	267.	.259E+18	.844E+19	.660E+17	.716E+16	.192E+16	.409E+17	.536E+22
10	.274	255.	.475E+17	.408E+19	.118E+17	.346E+16	.928E+15	.198E+17	.259E+22

4.0 RADIANCE FROM AN ATMOSPHERE IN LOCAL THERMODYNAMIC EQUILIBRIUM

If one assumes that a given infinitesimal volume of a gas is in local thermodynamic equilibrium (LTE) at some temperature, it follows that whatever amount of radiant energy is absorbed by this gas, an equal amount of energy must be re-emitted in order to maintain the equilibrium state. Furthermore, the spectrum of the radiation re-emitted will be determined by the black body or Planck function using Kirchhoff's law. This LTE model may be expected to be more nearly valid at the lower altitudes where collision frequencies are quite high. At the higher altitudes (≥ 25 km), one should expect non-equilibrium effects (NLTE) to be important. Indeed, Degges^[17] has been developing a comprehensive NLTE atmospheric radiance model for a number of years and other workers have studied the high altitude problem as well^[18]. The FASCODE Program could also be used for the NLTE case if vibrational or rotational temperatures and/or populations of states at higher altitudes were read in. Such data could be prepared by programs such as Degges' work.

Despite its shortcomings at higher altitudes, a LTE atmospheric radiance model can be very useful not only in the low altitude regime, where it rests on solid footing, but also in the higher regions where one may use it to characterize the degree of deviation of the NLTE situation from the equilibrium case. A number of workers have prepared LTE radiance models among which we want to mention the recent extension of the AFGL LOWTRAN model to include a radiance calculation^[2].

In this section we present the algorithms implemented in FASCODE to enable the calculation of atmospheric radiance along a given optical path assuming LTE along that path. To provide the most efficient calculation of the radiance, it was decided to calculate its value layer-by-layer along with the spectral absorptance calculation described in the previous section. It should be noted that the radiance of a path proceeding from lower toward higher levels is not the same as that for the same geometrical path proceeding from higher to the lower layers. Figure 4.1 presents a sketch of two such paths, space-to-ground (Figure 4.1a) and ground-to-space (Figure 4.1b). A four-layer atmosphere has been shown for simplicity, each layer being labeled by the letter A, B, C, or D. The boundaries between each layer have

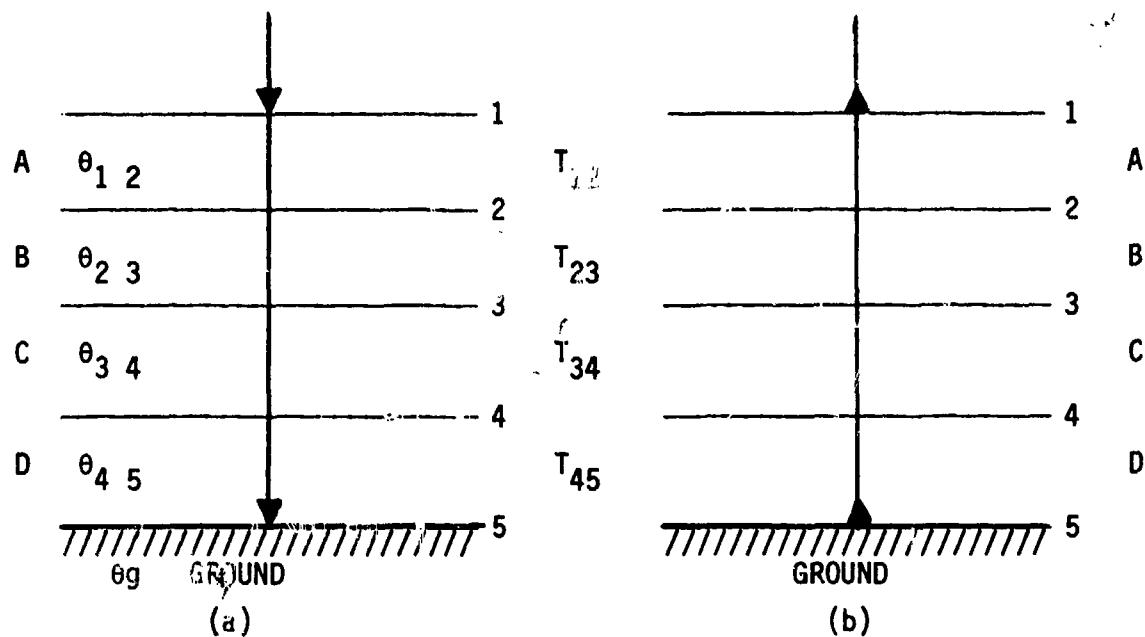


Figure 4.1: Sketch of the difference between a path looking up and one looking down.

been numbered from 1 to 5 where 5 is the ground at temperature at θ_g . The temperature of each layer is called θ_i , $i+1$ where i is one of the labels for the boundaries. The transmittance contributions between any two boundaries are defined as T_{ij} where i and j are boundary indices.

Consider now the equilibrium radiance from Layer A to space in Figure 4.1a. Using Kirchhoff's law this may be written as

$$R_{A-S} = (1 - T_{12}) P(\theta_{12}, \nu) \quad (4.1)$$

where P is the Planck function and ν is the frequency in cm^{-1} . Proceeding to the next layer the contribution of this layer to the radiance observed in space is

$$R_{B-S} = T_{12}(1 - T_{23}) P(\theta_{23}, \nu) \quad (4.2)$$

and the remaining two layers can be written as

$$\begin{aligned} R_{C-S} &= T_{12} T_{23} (1 - T_{34}) P(\theta_{34}, \nu) \\ &= T_{13}(1 - T_{45}) P(\theta_{34}, \nu) \end{aligned} \quad (4.3)$$

and

$$\begin{aligned} R_{D-S} &= T_{12} T_{23} T_{34}(1 - T_{45}) P(\theta_{45}, \nu) \\ &= T_{14}(1 - T_{45}) P(\theta_{45}, \nu) \end{aligned} \quad (4.4)$$

Finally the contribution of the ground is

$$R_{g-s} = T_{12} T_{23} T_{34} T_{45} P(\theta_g, \nu) = T_{15} P(\theta_g, \nu) \quad (4.5)$$

The total radiance is then the sum of all these terms. Extending this to

the case of n layers with $n + 1$ boundaries we can write

$$R_{\text{total}}^{(\text{down})} = \sum_{i=1}^n T_{1,i} (1 - T_{i,i+1}) P(\theta_{i,i+1}, \nu) \quad (4.6)$$

$$+ T_{1,n+1} P(\theta_{n+1}, \nu)$$

where now θ_{n+1} is a temperature characteristic of the last boundary. Note that in general, this is not necessarily the ground. (It shall be noted

$T_{ij} = \prod_{k=1}^j T_{k,k+1}$.) Also, it is not required that the spectral distribution at the boundary be given by the Planck function. An arbitrary spectrum or one characteristic of a particular type of radiating boundary may be substituted for the $(n+1)$ 'st term.

Turning now to the other case, looking up, we can write the following expression for the contribution to the radiance from each of the layers

$$R_{5-4} = (1 - T_{45}) P(\theta_{45}, \nu) \quad (4.7)$$

$$R_{4-3} = T_{45} (1 - T_{34}) P(\theta_{34}, \nu) \quad (4.8)$$

$$R_{3-2} = T_{34} T_{45} (1 - T_{23}) P(\theta_{23}, \nu) \quad (4.9)$$

$$= T_{35} (1 - T_{23}) P(\theta_{23}, \nu)$$

and

$$R_{2-1} = T_{23} T_{34} T_{45} (1 - T_{12}) P(\theta_{12}, \nu) \quad (4.10)$$

$$= T_{25} (1 - T_{12}) P(\theta_{12}, \nu)$$

Again, the total radiance is the sum of the individual terms for each layer which may be written as

$$R_{(total)}^{(up)} = \sum_{i=0}^{n-1} T_{n-i, n} (1 - T_{n-i-1, n-i}) P(\theta_{n-i-1, n-i}, \nu) + T_{1, n+1} P(\theta_1, \nu) \quad (4.11)$$

where we have implicitly defined $T_{1,1} = 1$ for convenience. To present a radiating boundary at the end of an upward looking path, such as a cloud or the Zodiacal light, one may add the same type of boundary radiating term as discussed for the downlooking case. An upward looking boundary has not been included in FASCODE as yet but a user can readily add one if it should be required. A glance at Equations (4.6) and (4.11) is sufficient to see the difference between each case.

The expressions in (4.6) and (4.11) are convenient mathematical representations of the algorithm but for computational purposes it is more useful to represent the algorithms such that they manipulate the new increment to the transmittance for a given layer i , and the radiance and total transmittance accumulated up to that layer. As was mentioned in Section 3, the calculation proceeds from the lowest layer to the highest in order to minimize the time for merging. If ΔT_i is the incremental transmittance, $E(i)$ the radiance and $P(i)$ the Planck function, the radiance and transmittance after the i^{th} layer has been traversed are

$$E(i)^{(up)} = E(i-1)^{(up)} + (1 - \Delta T_i) P(i) \cdot T(i-1) \quad (4.12)$$

and

$$E(i)^{(down)} = \Delta T_i E(i-1)^{(down)} + (1 - \Delta T_i) P(i) \quad (4.13)$$

for the radiance looking up and looking down, respectively. The transmittance is clearly given by the relation (for both cases)

$$T(i) = \Delta T_i \cdot T(i-1) \quad (4.14)$$

The boundary radiance is frequently not a function with very fine spectral resolution. Thus, for the lookingdown case, the most efficient procedure is to compute the boundary radiance at the coarse resolution of the lowest layer and include it with the radiance of the first layer (modified by the transmittance, of course). This will then be properly carried along through the remainder of the calculation. For the case of a radiating boundary at the upper end of a path looking toward space, it is simplest to add the contribution from the boundary after all calculations have been performed modifying it by the total transmittance computed for the path. As mentioned above, FASCODE at this juncture does not include coding for this second case, but does include a radiating boundary at the end of a down-looking path.

In order to speed up the calculation of the Planck function the following procedure was followed. For each panel, the black body function is computed and the results stored in an array with separation of one wave number. The value needed at a given wave number is obtained by interpolation which is performed only when the value of the Planck function can be expected to have changed sufficiently to warrant an updated value. If the Planck function is written

$$P(\nu) = A\nu^3 (e^{s\nu} - 1)^{-1} \quad (4.15)$$

where ν is in wave numbers and $s = C_2/\theta$, θ being the temperature, and C_2 the second radiation constant (1.4388). Taking the derivative with respect to ν we may write

$$\frac{dP}{P} = \frac{d\nu}{\nu} \left[3 - (s\nu) (1 - e^{-s\nu})^{-1} \right] \quad (4.16)$$

If one takes $|\Delta P/P| \lesssim 10^{-4}$, the increment at which one should interpolate to obtain a new value of the Planck function is easily computed. This alleviates the need to recalculate the Planck function unnecessarily.

The implementation of this algorithm for LTE radiance in FASCODE is contained in two subroutines, EMUP and EMDOWN, for paths "looking" up toward space and "looking" down toward the ground respectively. An additional subroutine was prepared to compute the first layer (the lowest), EMINIT. In this routine the possibility of radiation from a boundary was included for the downward-looking case.

The merging of the results layer-by-layer proceeds in a similar fashion to that for the absorptance described in Section 3. One difference is that now one needs to merge two quantities, namely, the radiance computed and the transmittance as the calculation proceeds from layer to layer. These quantities are written to disk in two records, first the radiance, followed by the transmittance. The code accesses the HIRAC algorithm to obtain the spectral absorptance panel by panel for each layer. This information is converted to transmittance by exponentiation in either EMUP or EMDOWN depending on the case of interest. The LTE radiance algorithm is then exercised as the merging is taking place.

The radiance routines were tested in a manner similar to the merging test described in the last section. Consider the case of a series of n layers with a path from space to ground with a boundary at temperature θ . If one modifies the input data such that each layer has the same temperature as the boundary, then one can show that the resulting radiance will be given by the Planck function at temperature θ , a result which is not at all surprising. The same result holds for the upward looking case if a boundary is added at the upper end and the temperatures are all set equal. This procedure was followed with the results as expected to within accuracy requirements inherent in the method.

The radiance package has been tested for the problem described in the previous section. The radiance results are shown in Figures 4.2 together with the transmittance for a path looking from space to ground which is modeled as a black body radiator with temperature, $T = 273$ K. Note the smaller range of the abscissa for Figures 4.2(e) and 4.2(f). The absorption features seen in Figures 4.2 are clearly seen in the radiance profiles as well. The expanded frequency scale in Figures 4.2(e) and 4.2(f) show this most clearly. Self-reversal can easily be seen in the radiance for strong absorption lines.

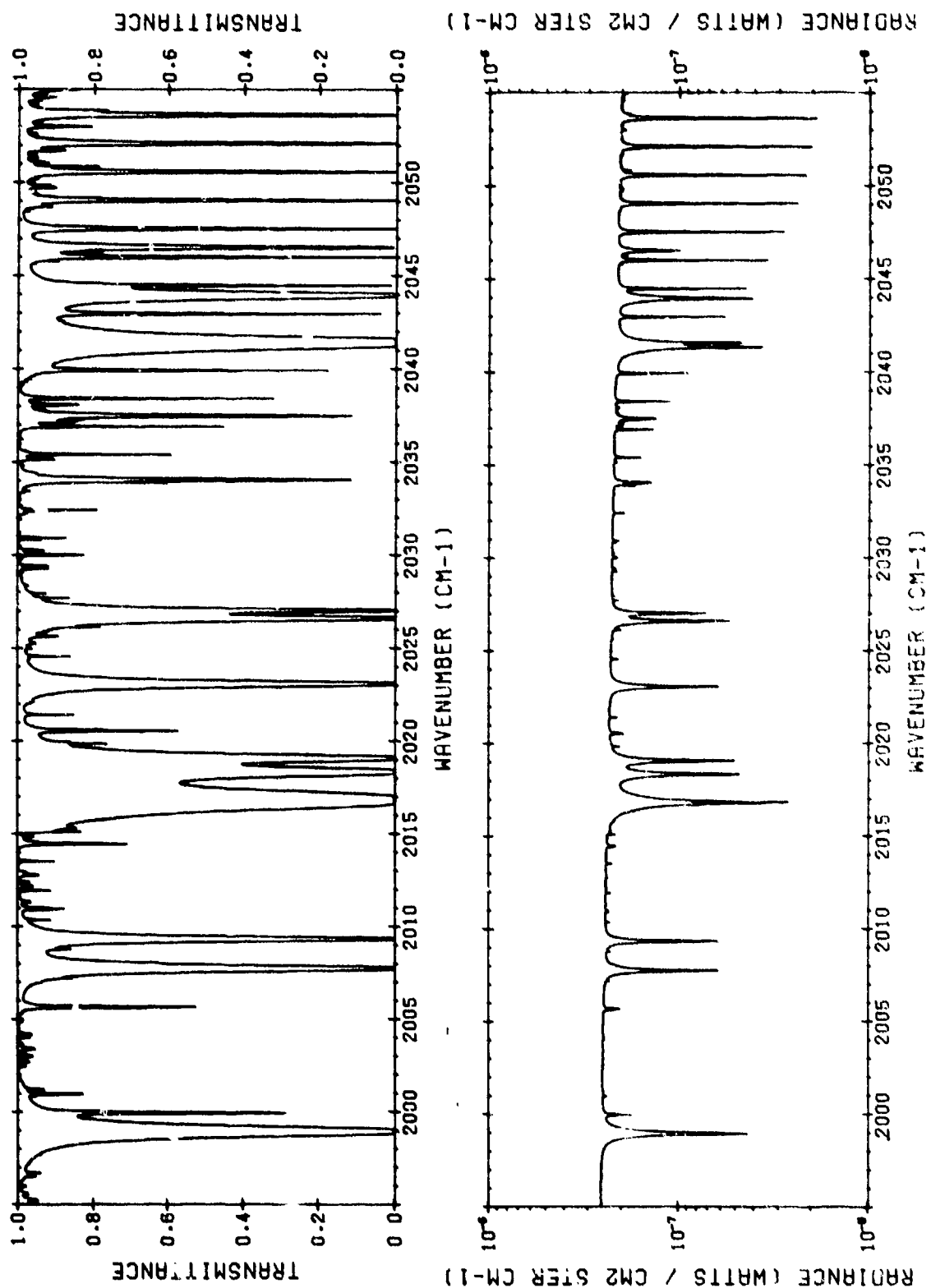


Figure 4.2 (a): Transmittance and radiance for the test problem (1995-2055 cm^{-1})

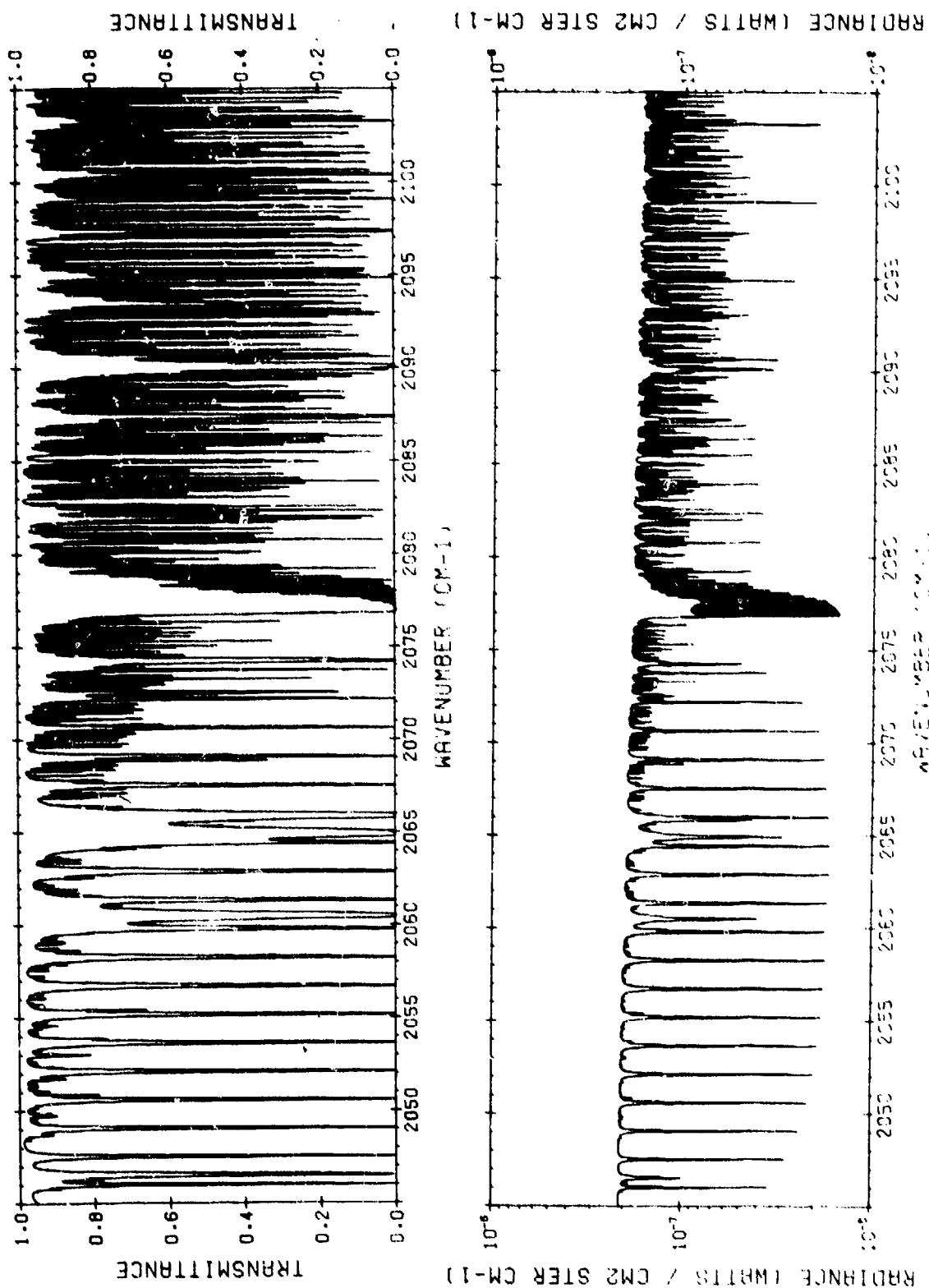


Figure 4.2 (b): Transmittance and radiance for the test problem (2045-2105 cm^{-1}).

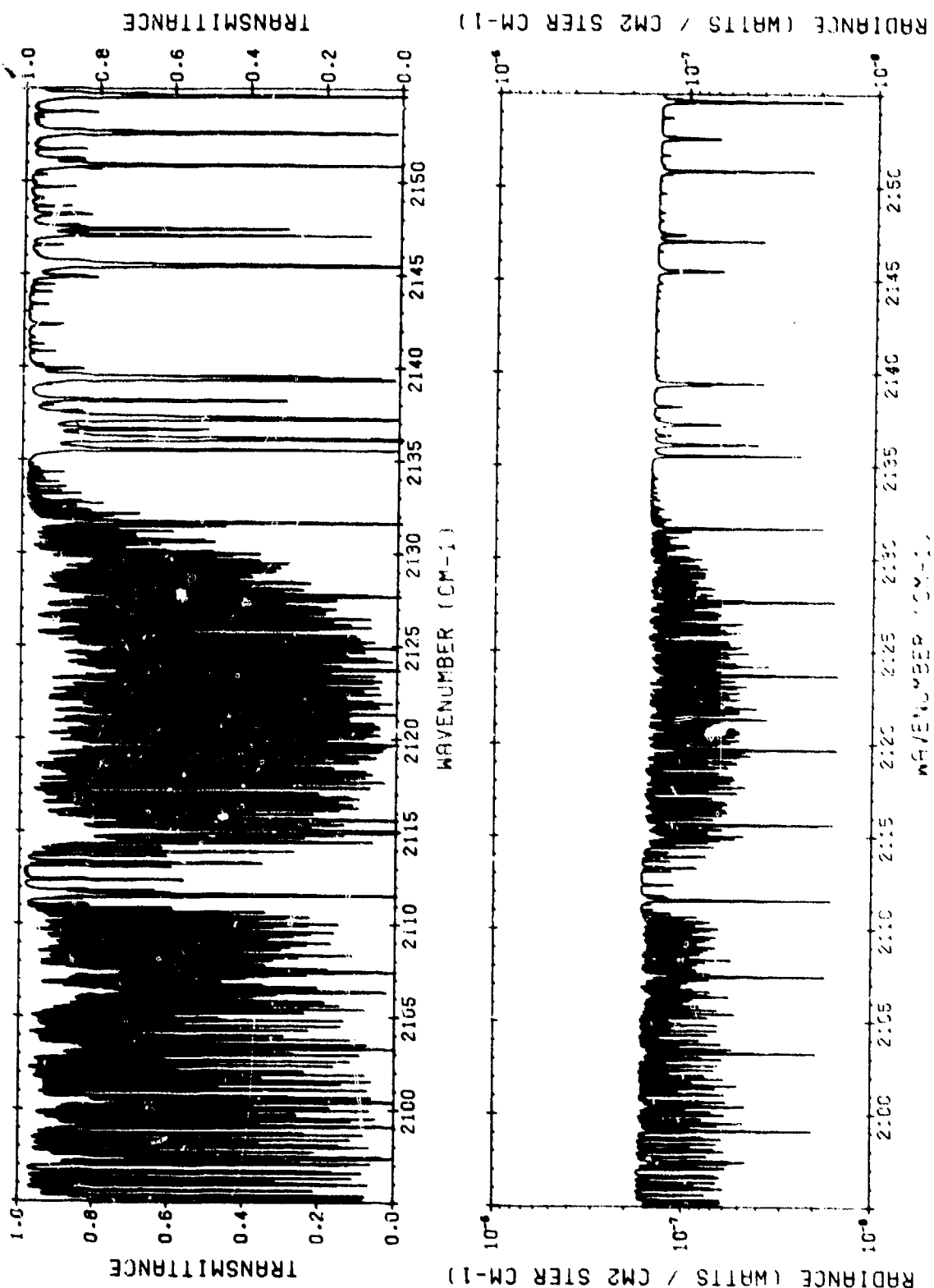


Figure 4.2 (c): Transmittance and radiance for the test problem (2095-2155 cm^{-1}).

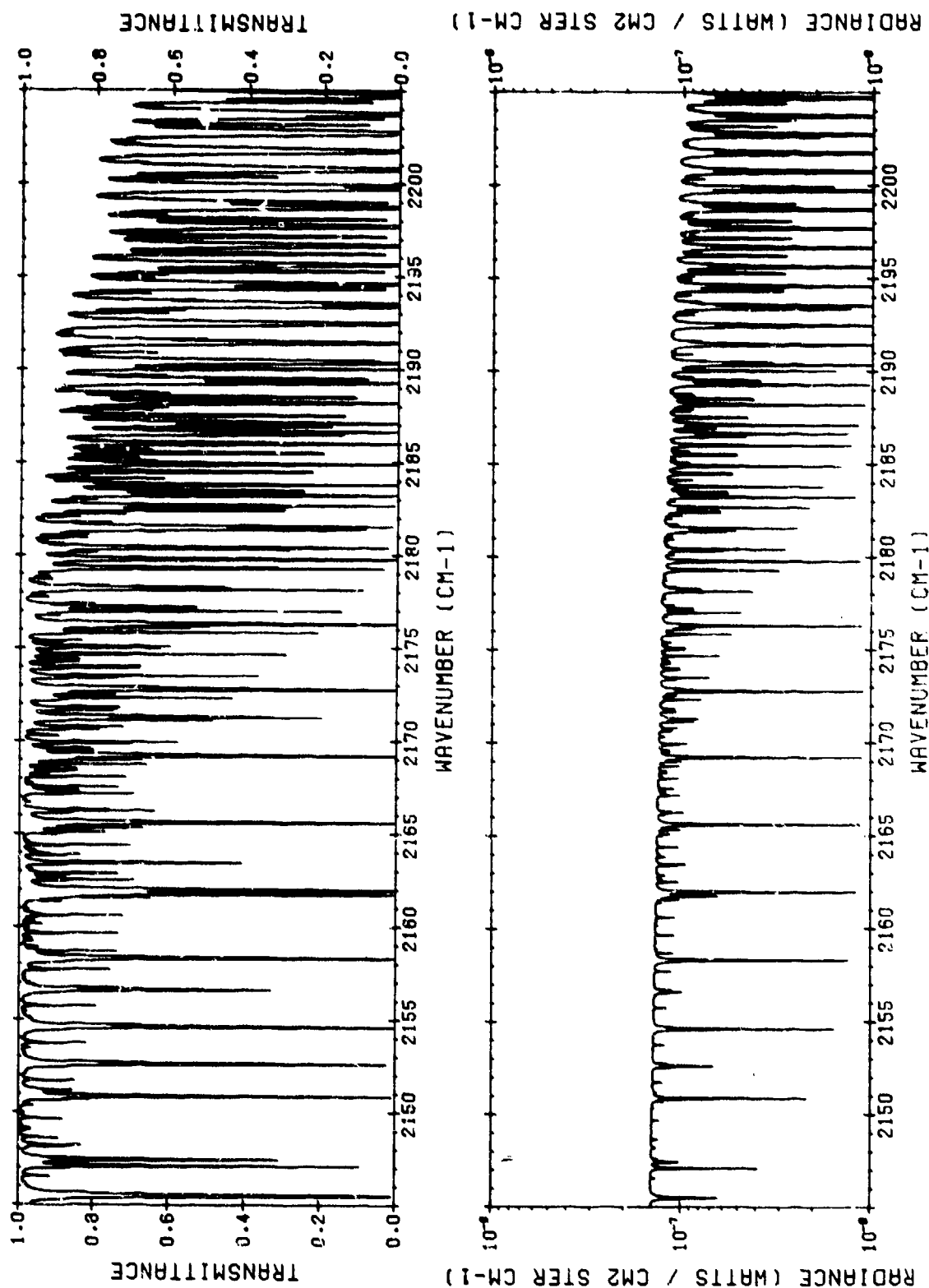


Figure 4.2 (d): Transmittance and radiance for the test problem ($2145\text{-}2205 \text{ cm}^{-1}$).

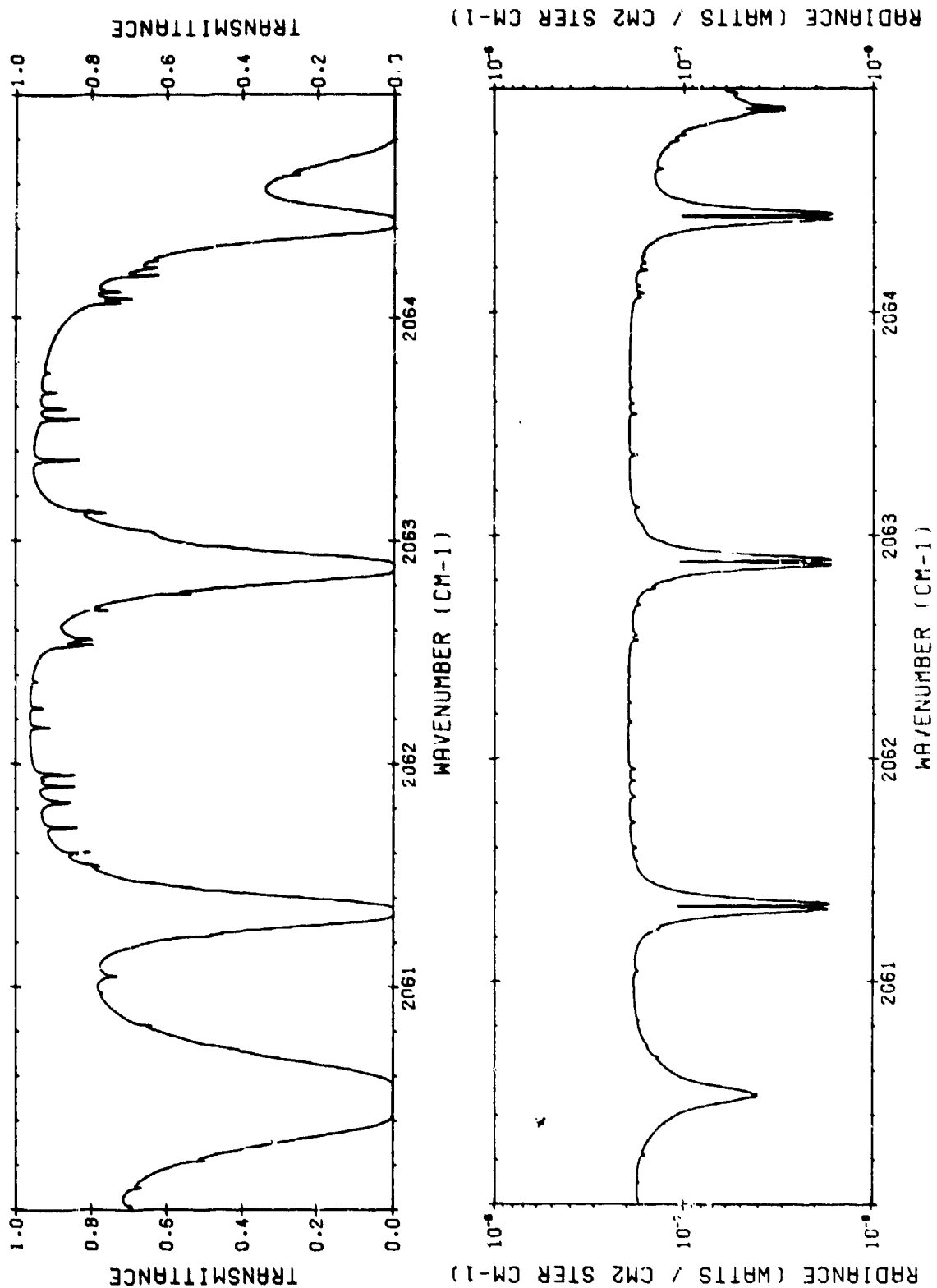


Figure 4.2 (e): Transmittance and radiance for the test problem with expanded scale (2060-2065 cm^{-1}).

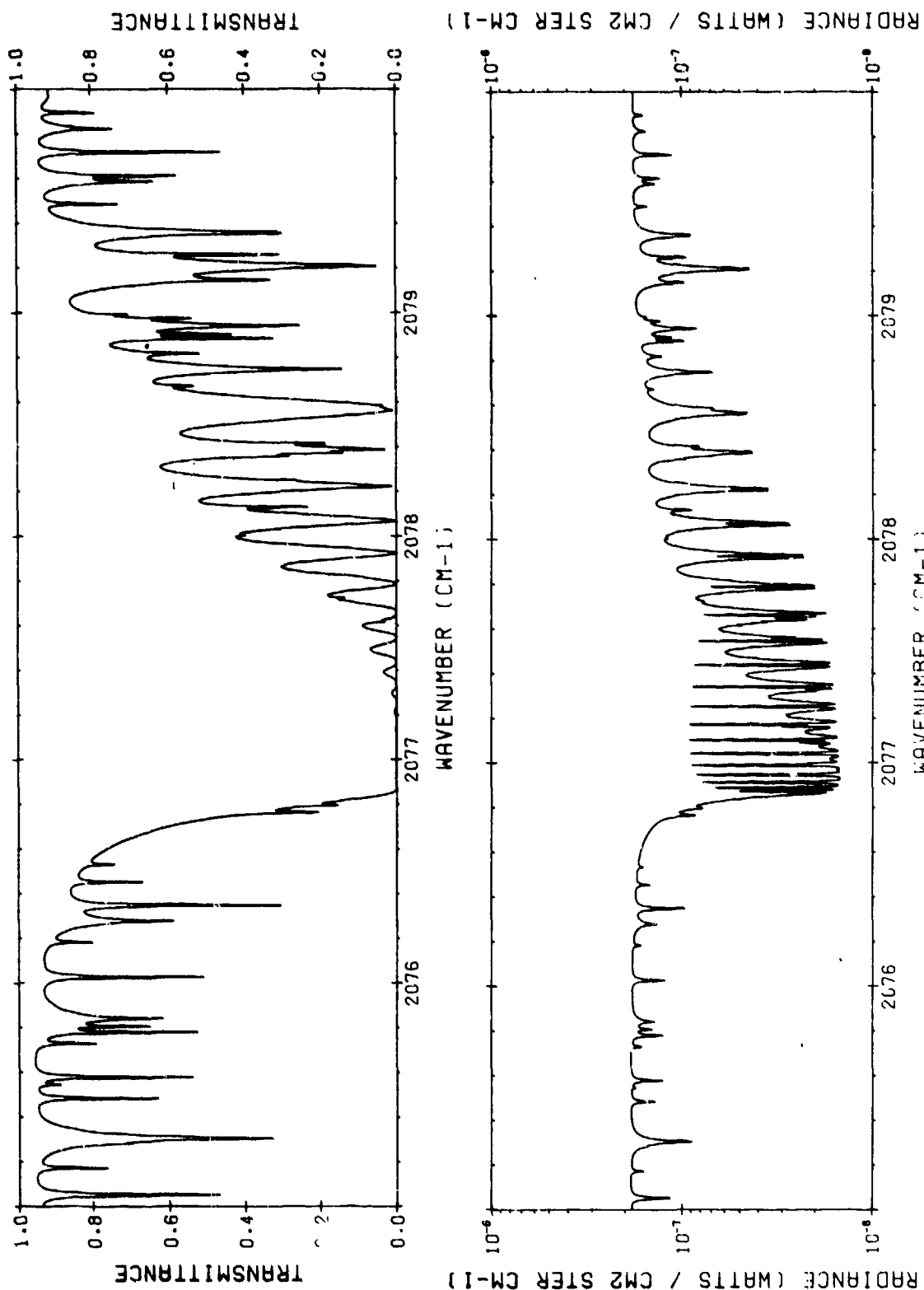


Figure 4.2 (f): Transmittance and radiance for the test problem with an expanded scale (2075-2080 cm^{-1}).

This is particularly dramatic in Figure 4.2(f) near the band edge of the CO₂ (11101-00001) transition.

In Table 4.1 we give the time results of the run made to produce Figures 4.2. All times are for the CDC 6600 computer system at AFGL. For each of the layers of the test problem, we give the altitude boundaries and the temperature and pressure characterizing each layer. The next column gives the value of λ used in computing the Voigt shapes for that layer. The average linewidth and the sampling interval are given in the columns labeled ALPHA and DV respectively. The ratios of the sampling intervals are given in the following column. The final four columns show the timing for the convolution of the spectra (CONV), the writing of the panels to disk (PANEL), the calculation of the radiance (EM) and the calculation of the transmittance merging (ABS). The sums of the times for each column are also presented. Note that the total number of lines processed was 6681. The convolution took approximately 0.7 msec per line per layer. This latter statistic is very meaningful, since it gives the reader some idea of the speed of the program. The total time for a transmittance calculation only, may be obtained by summing the totals of the columns marked CONV, PANEL and ABS (i.e., 102.2 seconds). For the radiance calculation along the same path, one obtains the total time by summing the totals of the columns marked CONV, PANEL and EM (i.e., 175.3 seconds).

TABLE 4.1. TIMING RESULTS FOR THE TEST PROBLEM

Layer	Alt. km	Press. mb	Temp. K	Zeta	Alpha cm^{-1}	DV cm^{-1}	$\frac{DV_i}{DV_{i-1}}$	CONV sec	PANEL sec	EM sec	ABS sec
1	4-7	525.9	264.4	0.95	0.04396	0.01380		4.6	0.2	0.7	
2	7-11	332.9	242.7	0.94	0.02919	0.00920	3:2	4.5	0.3	1.8	0.8
3	11-14	197.6	222.9	0.90	0.01823	0.00613	3:2	4.1	0.4	2.7	1.1
4	14-17	124.0	216.0	0.86	0.01181	0.00307	2:1	5.2	0.9	5.1	2.2
5	17-20	77.27	216.9	0.79	0.00763	0.00230	4:3	4.5	1.2	7.1	3.1
6	20-30	36.60	223.9	0.64	0.00419	0.00115	2:1	4.9	2.4	13.5	5.8
7	30-40	8.340	243.0	0.28	0.00230	0.000575	2:1	5.3	4.7	26.6	11.7
8	40-45	2.551	263.3	0.10	0.00207	0.000575	1:1	4.8	4.7	15.4	2.0
9	45-54	1.156	267.3	0.048	0.00202	0.000575	1:1	4.7	4.7	15.5	2.1
10	54-∞	0.2742	255.4	0.012	0.00193	0.000575	1:1	4.5	4.7	15.6	2.1
TOTAL								47.1	24.2	104.0	30.9

5,681 Lines 2000 to 2200 cm^{-1}

5.0 CONCLUSIONS AND RECOMMENDED EXTENSIONS OF THE PROGRAM

For certain purposes it is helpful to use a pure Lorentz or a pure Doppler line profile instead of the Voigt profile, which takes slightly more computational time than the Lorentz line shape or the Doppler line shape alone. For example, a user might have a problem involving only transmission at the very high layers of the atmosphere, (≥ 40 km) in which region the line shape is purely Doppler. On the other hand, one might be interested in studying a laboratory experiment at relatively high pressures for which the Lorentz profile is adequate. The addition of the pure Doppler and the pure Lorentz cases is straightforward and has been accomplished. The reader is referred to the program listing in Appendix 3. The revisions which were required for the pure Lorentz case include:

- a. Subroutine SHAPED is not needed.
- b. The least squares fits for the linear combination of the two profiles are not necessary (AVRAT, $a_{VD}(\zeta)$, $a_{VL}(\zeta)$, $C(\zeta)$).
- c. All program references to the quantity ζ are deleted.
- d. The final result is, of course, similar to the original HIRACC coding^[3]. Here it is called HIRACL.

For the pure Doppler case, the following differences arise:

- a. Subroutine SHAPEL is not used.
- b. Delete all ζ references.
- c. Only the FF array is used, VSF and SF are not needed.
- d. The resulting routine is called HIRACD.

Some care had to be taken to assure that the proper indexing is made.

The contributions of the various continuum features have not been included as yet^[1,2,14,20]. These features arise from a number of physical

processes such as absorption by atmospheric aerosols, and a variety of molecular continuum processes for molecules such as N_2 , CO_2 , H_2O . In addition the contributions of the lines beyond 64 half-widths must also be included as part of the continuum contribution. In general, the continuum absorption is a slow function of wave number and may be directly incorporated into the VSF array. This operation will not significantly affect the running time of the program.

The line-by-line results have finer spectral detail than is required for comparison with some experiments. Some instrumentation (especially that used for engineering systems) does not have resolution such that the final spectral detail computed in this version of FASCODE can be resolved. A method is required for convolving a given instrument scanning function with the FASCODE output in order to degrade the detailed results for comparison with lower resolution data. Work on this aspect is currently underway at AFGL. We note that the convolution techniques used in the line-by-line spectral synthesis (HIRACC algorithm) may also be applied to a scanning function convolution.

When the sampling interval is constant from one layer to the next, and one is not calculating the radiance, it seems clearly possible to devise a new method which would decrease the running time considerably. This method would compute at the same time the spectrum for all of those adjacent layers which have a constant sampling interval. For example, above a certain altitude where the Doppler line shape becomes dominant, essentially all of the sampling intervals can be taken to be constant and the merging calculations for all of these layers can be done panel by panel.

Finally, for applications in systems studies it is recommended that spherical geometry be added which could account for the fact that the earth's atmosphere is not plane parallel, but rather spherical. With this addition to the code, the calculation of limb radiance would be easily performed and practical applications could be taken directly from FASCODE.

To illustrate this, consider a remote sensing satellite viewing the earth on some sight path. If the sight path ends on the earth's surface or some other surface above the earth such as a cloud layer, no great extension to the program need be made. One merely needs to program a method for computing column densities of the absorbing molecules for each layer. However,

for the case of a sight path that is glancing, or tangent to some altitude above the earth, the problem is more complicated.

Figure 5.1 is a sketch of this case. Here r_{\max} is the earth-centered radius to the maximum altitude for which calculations are to be made, and r_T is the corresponding radius to the tangent height at Point T. Let A and B be the points at which the line-of-sight intersects the circle of radius r_{\max} . First, we consider the case where only the transmittance is to be calculated. It is clear that the largest sampling interval which will be determined from the criteria programmed in FASCODE, will be found in the tangent height layer and the smallest will be for the layers ending at the two points A and B. Thus the optimum procedure will be to start at the tangent height where one has the smallest number of points needed to characterize the convolved spectral transmittance. Next, we note that the two paths TA and TB are identical compositions of column densities. Thus the transmittance from path TB is identical to that on path TA and the total transmittance may be obtained simply by doubling the contributions from each layer and computing only one of the two paths TA or TB. Note that it is the column densities which are to be doubled and not the transmittance. Also we have tacitly assumed that the atmospheric composition profiles do not change appreciably along the path ATB. Since the angle ACB can be as large as $\sim 20^\circ$, this may not be the case. Thus, for example, the sight path may enter the atmosphere at $\sim 45^\circ\text{N}$ latitude and exit at 65°N latitude and the profiles can be quite different, especially for water. This is a complication which may or not be important in a given case. No essential difficulties should occur, however, should this situation need to be investigated.

For the radiance calculation, it is again best to start at the tangent part of the sight path. This can be done simultaneously with the TB part corresponding to a path looking up and the TA part to a down-looking path. When the calculations for the two final layers are finished, the total radiance, R_{TOT} , is computed simply by the relation

$$R_{\text{TOT}} = R_{\text{TA}} + T_{\text{TA}} R_{\text{TB}} \quad (5.1)$$

where R_{TA} and R_{TB} are the results of the radiance calculations on paths TA and TB respectively, and T_{TA} is the transmittance from path TA. If Point B

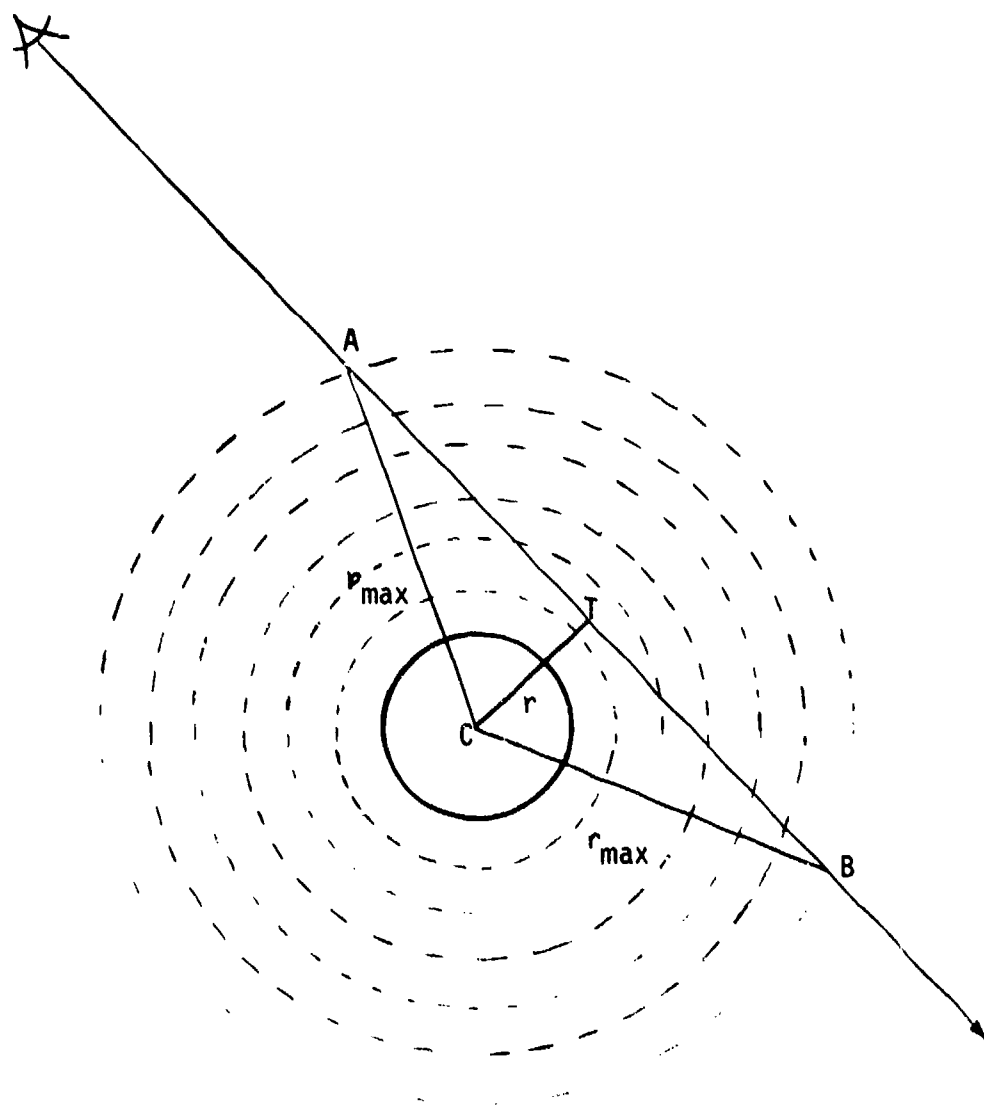


Figure 5.1: Sketch of Tangent Path Satellite Viewing Geometry.

is not at the same altitude as Point A (for example Point B corresponds to a target or a cloud), no essential problems occur. One merely stops the calculation along TA at the altitude of Point B, performs the composition of Equation (5.1) and continues the calculation to Point A as before, but using the value R_{TOT} for the radiance at the stopping point. This method has not been implemented as yet in FASCODE but the implementation should be straightforward.

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APPENDIX A

CODE STRUCTURE AND DESCRIPTION

In this appendix we present a description of the code. For the reader's convenience much of the documentation of the HIRACC algorithm^[3] has been reproduced here with an occasional modification. In addition, the new subroutines developed in this effort are described.

The program has been written to use line parameter input data consistent with that contained in the AFGL line parameter tape^[1]. The line data has been reformatted onto a binary file which contains the line data pertinent to the molecules and wave number range of interest. This step has been taken to keep read time consistent with the time required to perform the calculational part of the program. The control parameters are read from the input file and written to the output file; TAPE3 is the binary file containing the line parameter data; and TAPE12 is always the binary output file. The final output and intermediate output files contain a header record which includes the identification information, SECANT, temperature, pressure, molecular identification, and molecular column densities of the homogeneous layers. The first record for each output panel is a header record for the panel which contains the wave number values of the first and last absorption coefficient values of the panel, the wave number increment between output points and the number of output points. The second record of the panel contains either the array of absorption coefficient values resulting from the convolution when only absorptance is calculated or the radiance array followed immediately by the transmittance array for radiance calculations. The current version of the program outputs a maximum of 2400 values per panel; in general, the first and last panel are shorter. The output file MFILE, and an additional file, LFILE, are used to store the intermediate data prior to merging the results for the layers. The merged results are always on MFILE. The file KFILE contains the absorption coefficients for each layer. Table A1 outlines the use of these files and file labels.

FASCODE has been designed to be used with the CDC segmentation feature which allows the program to be run using a minimum of central memory by loading dynamically only those subprograms which are in use at a given stage of the code's execution. Using this feature, FASCODE requires only ~ 56 K_g words of central memory. If a user does not have a segmentation

TABLE A1. FILES USAGE

UNIT NAMES:

- INPUT(=TAPE5), OUTPUT(=TAPE6) - Standard I/O files
- TAPE3 - Absorption line data file in buffered binary format
- TAPE10 - Output file from HIRACV routine; labeled KFILE; buffered binary format. Data to be merged with data from previous layer (on LFILE) except for first layer.
- TAPE11 - Intermediate file used in merging layers; label alternates between LFILE and MFILE file structure - buffered binary format.
- TAPE12 - Final output file but used in intermediate merging of layers; indexing set to assure final result is on this unit; label may alternate between LFILE and MFILE but always MFILE=12 for final layer buffered binary format.

UNIT LABELS:

- KFILE - Contains HIRACV output for current layer - buffered binary
- LFILE - Contains results of previous layer - buffered binary
- MFILE - Contains merged results from KFILE and MFILE - buffered binary

capability on the machine being used, allowance will have to be made for a larger amount of central memory. In this case, storage allocation should be redistributed to minimize total storage requirement, estimated at 77 K₈. That is, long extension arrays in EMUP, EMDWN, and ABS should be changed to unlabelled common.

A simple overall structure of the code was obtained. This is shown schematically in Figure A.1. HIRACV and its associated subroutines perform the spectrum synthesis of the absorptance. The merging subroutine is called ABSMRG for the absorption coefficient case. The LTE radiance computations are performed by subroutines EMINIT, EMUP, and EMDOWN. Subroutine TPLLOT is an expanded version of the plotting program described in Reference [3], and it has been changed into subroutine form. Note that FASCODE can be used to prepare plots directly. Some possible future extensions of the program have been sketched as dotted lines in Figure A.1. The reader should note that the modular construction of the code allows straightforward extension and revisions.

The program consists of the main Program FASCODE: Subroutines ABSMRG, TPLLOT, EMINIT, EMUP, EMDOWN, HIRACV, SHAPED, SHAPEL, MOLEC, RDFILE, CONVFNV, PANEL, HIRACL, CONVFNL, HIRACD, CONVFND, and PANELD; and the Function QVRFAC. The overall strategy of the HIRACV Subroutine is indicated in Figure A.2. All the subroutines are called from the main program or from their subdriver (See Figure A.1) and the flow of the program is easily traced. Subroutines HIRACL and HIRACD perform the same functions for the Lorentz and Doppler line shape profiles respectively.

The main Program FASCODE reads the input data and calls each of the subdrivers shown in Figure A.1, according to the particular run desired as determined from the input. After initializing constants and reading the basic parameters for the run, the program enters a loop for the calculation of the requested results for each layer. Inside the loop the atmospheric properties, average temperature, average pressure and absorber molecule column densities are read from the input file for the given layer. The proper sampling interval is then computed and an identification header for the layer is buffered out to KFILE. Note that extensive use of BUFFER IN and BUFFER OUT is made to increase efficiency. If a user does not have this

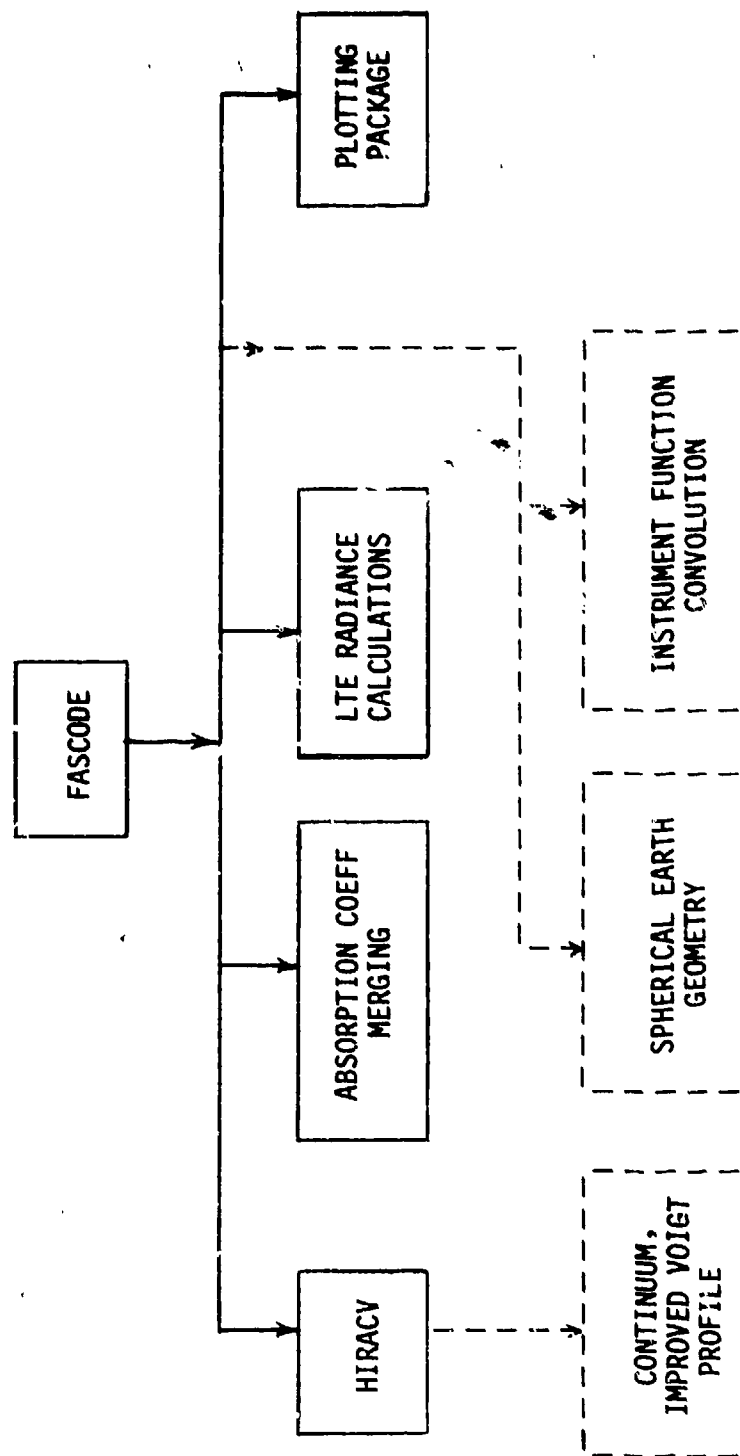


Figure A.1: FASCODE Overall Structure.

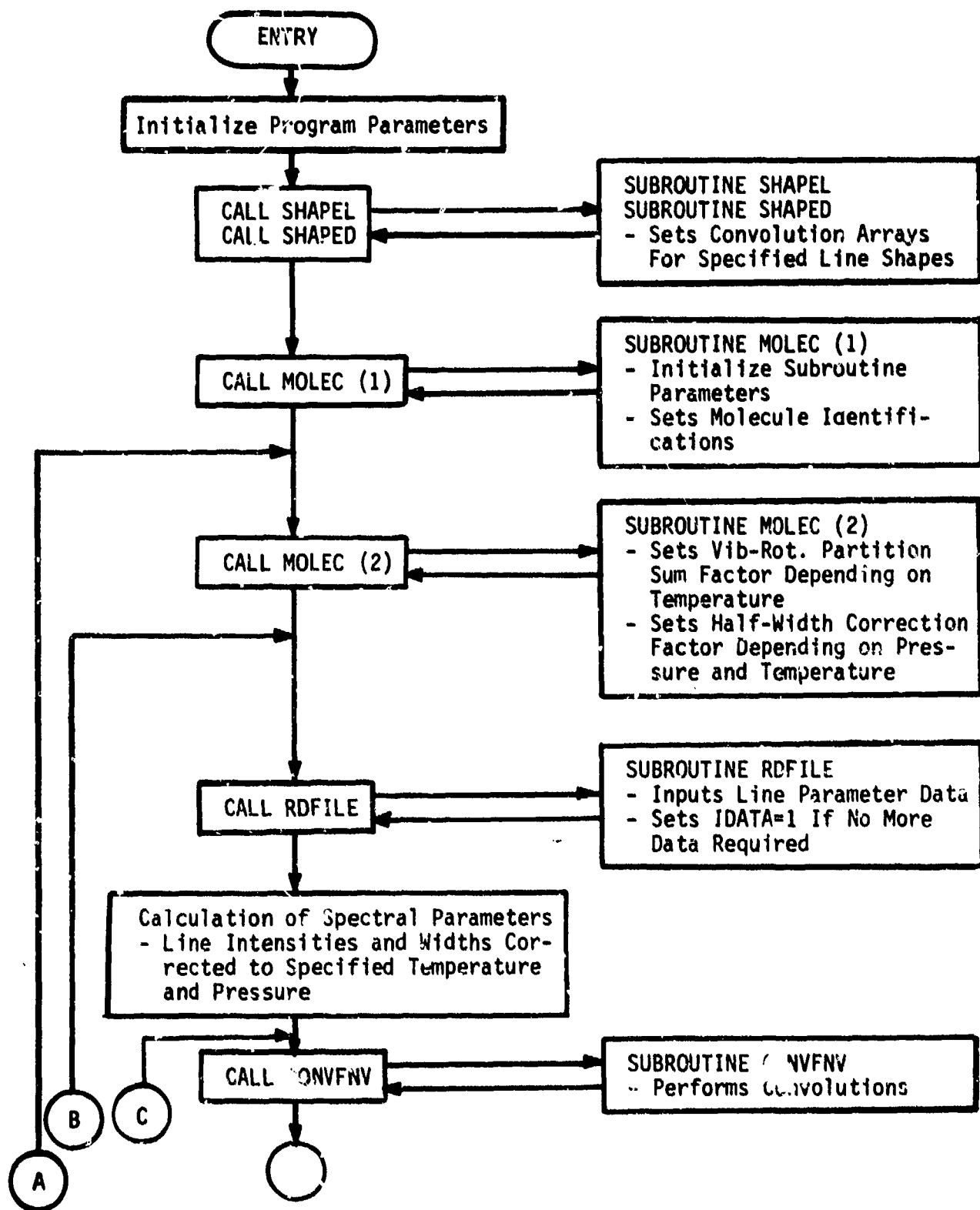


Figure A.2: Flow Diagram for HIRACV Subroutine

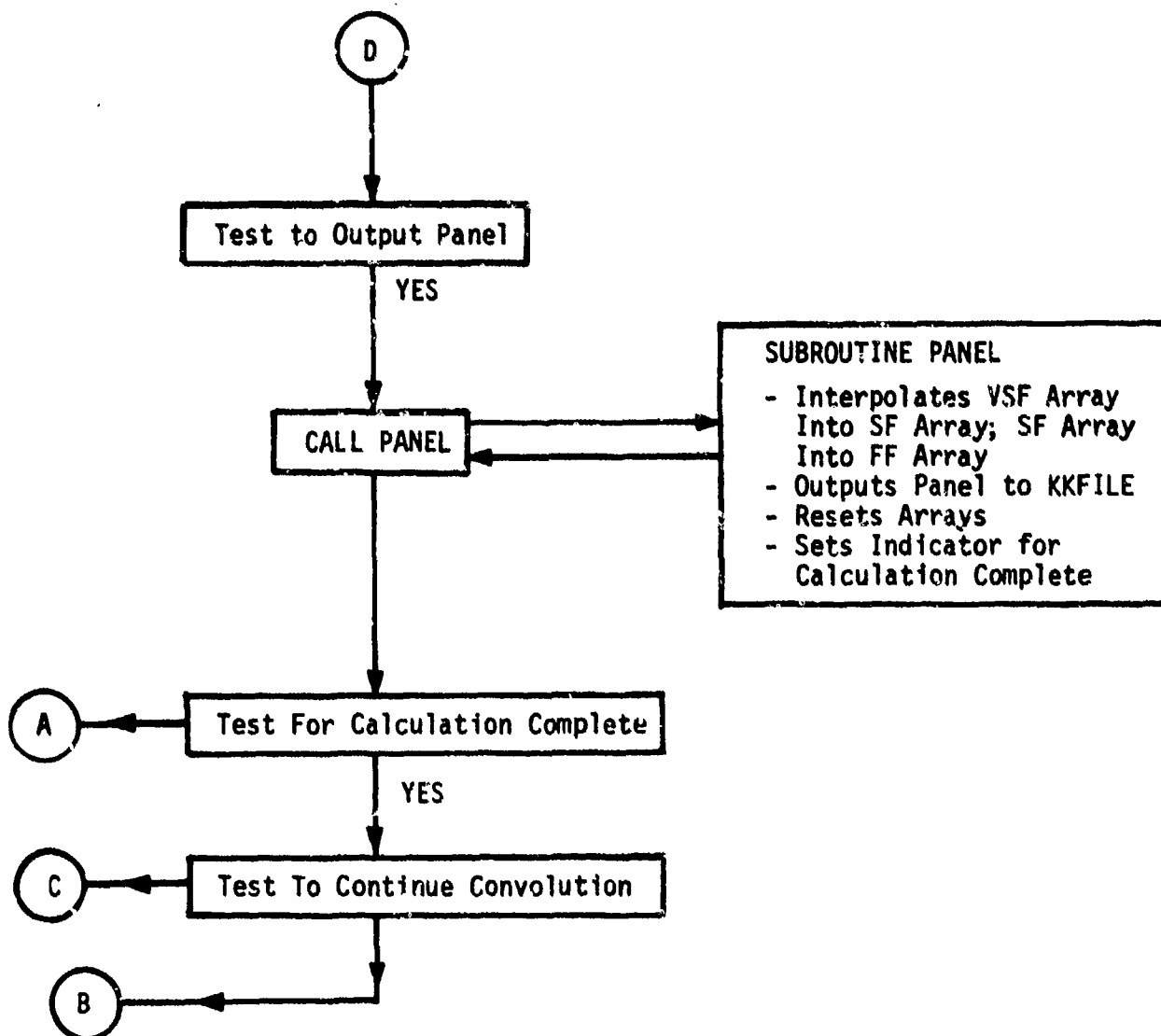


Figure A.2: Flow Diagram for HIRACV Subroutine (Continued)

capability, these statements can be replaced by binary read and write statements. Subroutine HIRACV is then accessed to compute the spectral absorptance. Once this has been completed, the appropriate merging routine is accessed, unless it is the first layer for which no merger is necessary. For the radiance calculation, Subroutine EMINIT is called to compute the radiance due to the first layer. For all other layers, the radiance is obtained by calls to EMDOWN or EMUP for the cases of looking down and looking up respectively. When all layers have been processed, the plotting Subroutine TPLLOT is called if the plot flag has been set by the user. Subroutines SHAPEL and SHAPED set up the convolution functions used to define the Voigt function from 0 to 64 half-widths.

Subroutine MOLEC in conjunction with Function QVRFAC, makes the molecular identifications associated with the line parameter file, and determines the correction factors for the line intensities (SCOR) and the half-widths (ALFCOR). The quantity, SCOR, is the correction factor due to the temperature dependence of the vibrational and rotational partition sums. The vibrational partition sum is calculated for a given molecular type as

$$Q_v(T) = \prod_{i=1}^N \frac{1}{(1 - e^{-h\nu_i/kT}) d_i} \quad (A-1)$$

where ν_i is a fundamental frequency and d_i is the degeneracy of the vibration. The temperature dependence of the rotational partition sum is given by

$$\frac{Q_R(T_0)}{Q_R(T)} \approx \left(\frac{T_0}{T} \right)^F \quad (A-2)$$

where $F = 1$ for linear molecules and 1.5 for nonlinear molecules. The reference temperature, T_0 , is taken as 296 K, consistent with the AFGL Line Listing. For further discussion of these topics, see Herzberg^[21] pp. 503 ff. The partition sum calculations are performed by QVRFAC and the necessary molecular parameters are contained in data statements in Subroutine MOLEC. The quantity, ALFCOR, is the correction factor due to the pressure and temperature dependence of the collision broadened half-width. The temperature

dependence of the half-width has been taken as $(T_0/T)^{0.5}$ although calculations based on the Anderson-Tsao-Curnutte theory are reported to give somewhat different temperature dependencies (Varanasi)^[22].

Subroutine RDFILE reads the blocked binary line parameters over the wave number range for which line data is required. The line parameters include the wave number value of the transition (GNU, cm^{-1}), the intensity of the transition at 296°K (S , $\text{cm}^{-1}/(\text{mol}/\text{cm}^2)$), the collision broadened half-width at half maximum for 296°K and 1 atm pressure (ALFA0, cm^{-1}), the lower state energy of the transition (EPP, cm^{-1}), and the molecule identification number (MOL). If the line parameter data is insufficient to complete the specified calculation, the message "end of file on disk" is printed on the output file. If no further line data is required, IDATA is set to 1, and control is returned to the main program.

At this stage of the main program, an effective optical depth is calculated for each line which is dependent on the column density of the layer, the secant of the angle through the layer, the temperature of the layer, and the half-width of the line $\alpha(\text{ALFI})$.

The effective depth, μ' ,

$$\mu' = \left(\frac{S(T)}{\alpha_V(T)} \right) \cdot w \cdot \sec \cdot \left(\frac{Q_{VR}(T_0)}{Q_{VR}(T)} \right) \cdot \left[\exp \left(\frac{E''}{kT_0} - \frac{E''}{kT} \right) \right] \cdot \left[\frac{1 - \exp \left(-\frac{h\nu}{kT} \right)}{1 - \exp \left(-\frac{h\nu}{kT_0} \right)} \right] \quad (\text{A-3})$$

where w is the absorber column density, E'' is the lower state energy, $Q_{VR} \equiv Q_V Q_R$, and the other quantities have been previously defined. In terms of the program coding the effective depth appears as:

$$\text{EFDPTH} = \text{SEC} * \text{W} * \text{S} * \text{SCOR} * \text{RECALF} * \left[\exp(\text{EPP}/\text{XKTFAC}) + (1 - \exp(-\text{GNU}/\text{XKT})) / (1 - \exp(-\text{GNU}/\text{XKTO})) \right]$$

where XKT and XKTO are the wave number values of T and T_0 in cm^{-1} . As

previously discussed, the proper sampling interval, DV, should be 0.25 times the average line half-width. If the half-width, ALFI, is less than the sampling interval, the half-width is set to the sampling interval and a series of minus signs is written to the output file. If the half-width exceeds a maximum value (ALFMAX) where $ALFMAX = BOUND/64$ and BOUND is the maximum value in wave numbers over which a line can be calculated, the half-width is reset to ALFMAX, and a series of + signs is written to the output file. Included in the records indicating the resetting of the half-width is the wave number value of the transition (GNU), the intensity (S) and the half-width (ALFA0) values of the transition from the line parameter tape, the calculated value of the half-width (ALFI), the value to which the half-width has been reset (DV or ALFMAX), and molecular identification number (M). If the number of half-width changes (NCHNG) exceeds 100, the computation is terminated.

Subroutine CONVFNV is a tightly written subprogram in which considerable effort has been taken to minimize operations in the DO 30 loop. This subroutine performs the triple convolution of XF, XS, and XVS with a line datum putting the results in the proper elements of FF, SF, and VSF respectively. A simplified flow diagram appears in Figure A.3. Control indicator IPANEL is set to IDATA if the DO loop over the lines (40) is satisfied indicating whether a panel is complete or more lines are required. If the line DO loop (40) is not completed, IPANEL is set to 1 indicating that a complete panel has been calculated. Control is returned to the main program.

If IPANEL has been set to 1, Subroutine PANEL is called. Subroutine PANEL performs a four-point Lagrange interpolation of the VSF array into the SF array and the SF array into the FF array, thus combining the results of three independent convolutions into a final result. A general flow diagram of PANEL is given in Figure A.4. Care is taken to store array values required for the interpolation of subsequent panels. VFT is the wave number value of the first element of the FF array, which is common to the first element of the SF and VSF arrays. A binary header record is written to the binary file (KFILE) for each panel which includes the wave number value (VIP) of the first element of the panel (FF(NLO)), the wave number value (V2P) of the last element of the panel (FF(NHI)), the wave number increment (DV), and the number

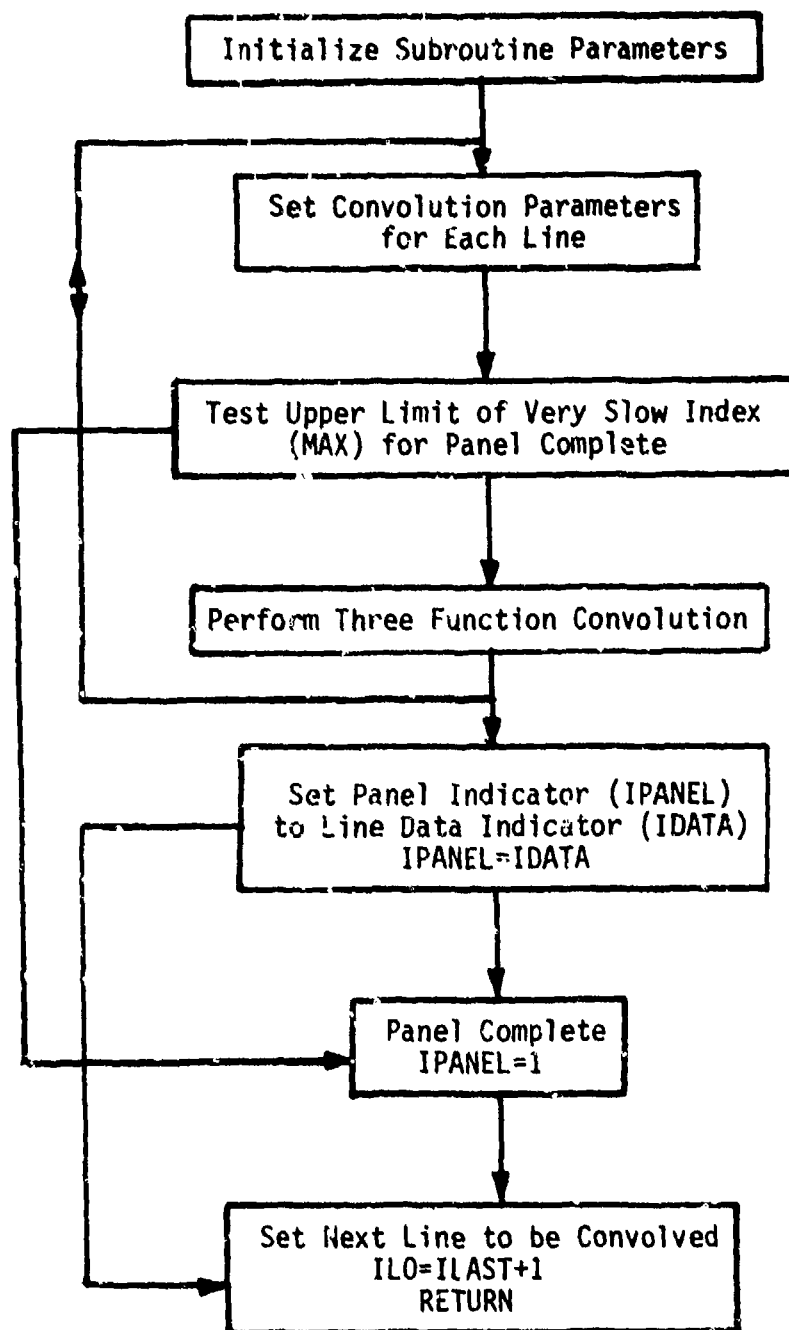


Figure A.3: Flow Diagram for SUBROUTINE CONVFNV.

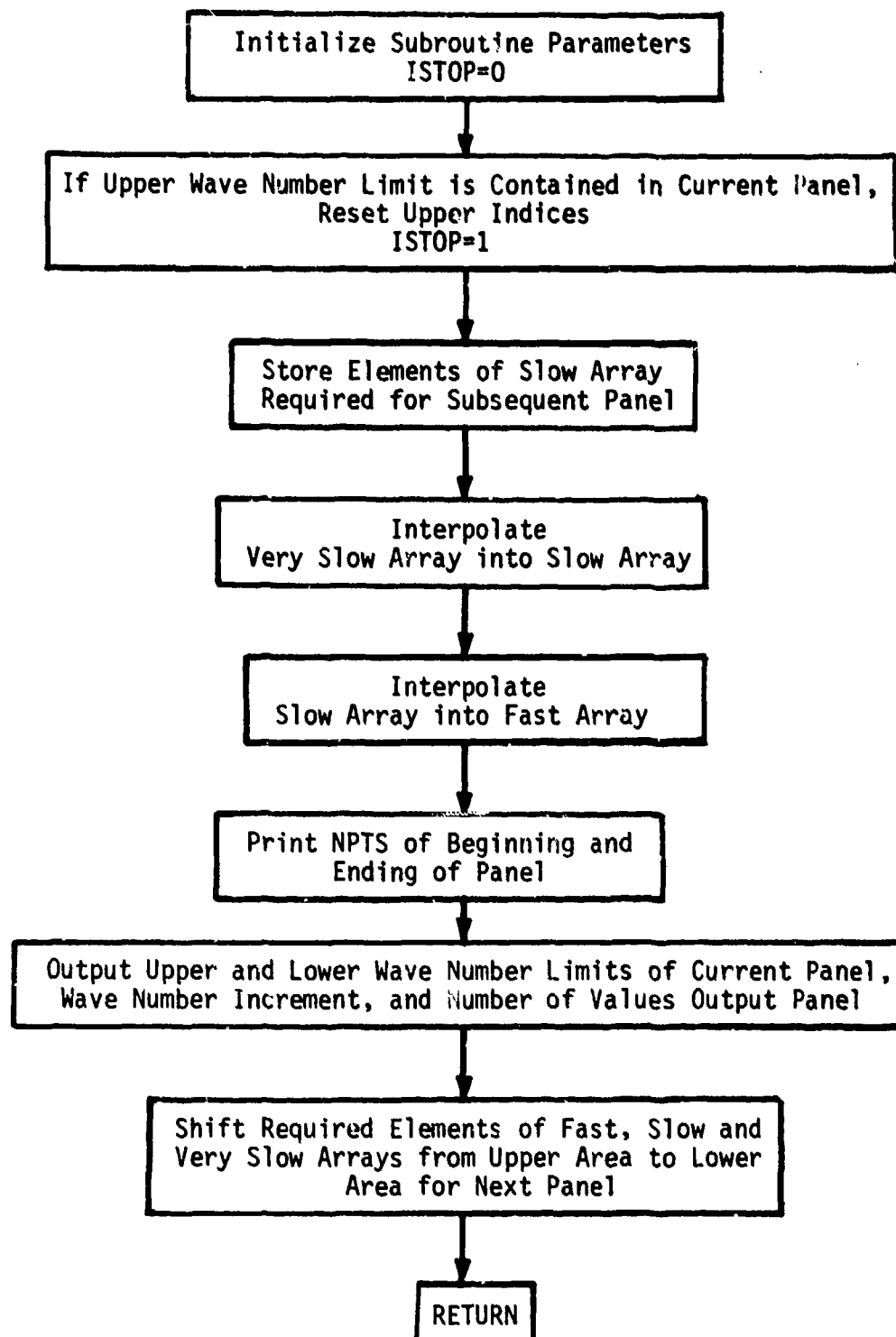


Figure A.4: Flow Diagram for SUBROUTINE PANEL.

of absorption coefficient values outputted (NLIM). The second binary record contains the NLIM values of the absorption coefficient from the FF array. The arrays are appropriately shifted and reset in preparation of the computation of subsequent panels. Control is again returned to the main Subroutine HIRACV.

At the conclusion of the outputting of the last panel for each layer, a record is written to the output file indicating the current value of the time, the time spent in RDFILE, in CONVFN, and in PANEL (the units are seconds). Also included in this record are the first and last wave number values of the panel. A second record is written to the output file indicating the average value of the half-width, the number of lines read since the last panel was completed, and the total number of lines read since the initiation of the convolution calculation. Control is returned to Statement 10 if the calculation is complete, or to Statement 40 to continue the convolution in process.

ABSMRG -- Absorption Merging

Subroutine ABSMRG performs the merging of the absorption layer-by-layer along a path. The absorption at the present layer and the accumulated absorption from previous layers are read from disk files. The constant ISMALL, computed in FASCODE, is used to identify whether the present or the accumulated layer has the smaller wave number increment. BUFFER IN and BUFFER OUT are used rather than READ and WRITE for speed of running. The array FF contains the absorption from the smaller increment and DUMF, the absorption from the larger. The index ITYPE, computed in FASCODE, gives the value of the numerator of the ratio of the two increments. The coefficients for the Lagrange four-point interpolation are computed and an interpolation is made for the absorption in the layer with the larger increment. The merging of the two layers is then carried out such that the merged absorptance has an increment equal to the smaller sampling interval. The output file contains a header record containing identification information, the values of the secant, pressure and temperature concentrations of the absorbing molecules, wave number increment, the value of the first, and last wave number in the panel and a layer count. Each panel's output consists of two records. The first record contains the first and last wave number in the panel, the wave number increment and the number of points in the panel. The second record contains the accumulated absorption. For speed of computation, if the wave

number increment is the same for both layers, the merging is done directly by merely adding the corresponding values. A simplified flow diagram is shown in Figure A.5.

Subroutine EMINIT computes the LTE radiance for the first altitude layer only. The Planck function is computed as described in the text. There is also the option of the radiance from a boundary, for the case of looking down. A simplified flow chart is given in Figure A.6. The radiance for the case looking from the space to ground is computed by the formula

$$NEWEM = (1 - TR) * BB + TR * OLDEM$$

The radiance from ground to space uses the formula

$$NEWEM = (1 - TR) * BB$$

where TR is the incremental transmission of the layer, BB the Planck function and OLDEM the radiance from the boundary when it is requested. Otherwise, it is zero. The results of the calculation are written on a file consisting of four records:

1. A header record containing alpha-numeric information supplied from FASCODE in the first seven words, the values of the secant, the pressure, average temperature, concentrations of the absorbing molecules, DV, first and last wave numbers and a layer count.
2. V1, V2, DV and the number of points in the panel.
3. The radiance.
4. The transmission

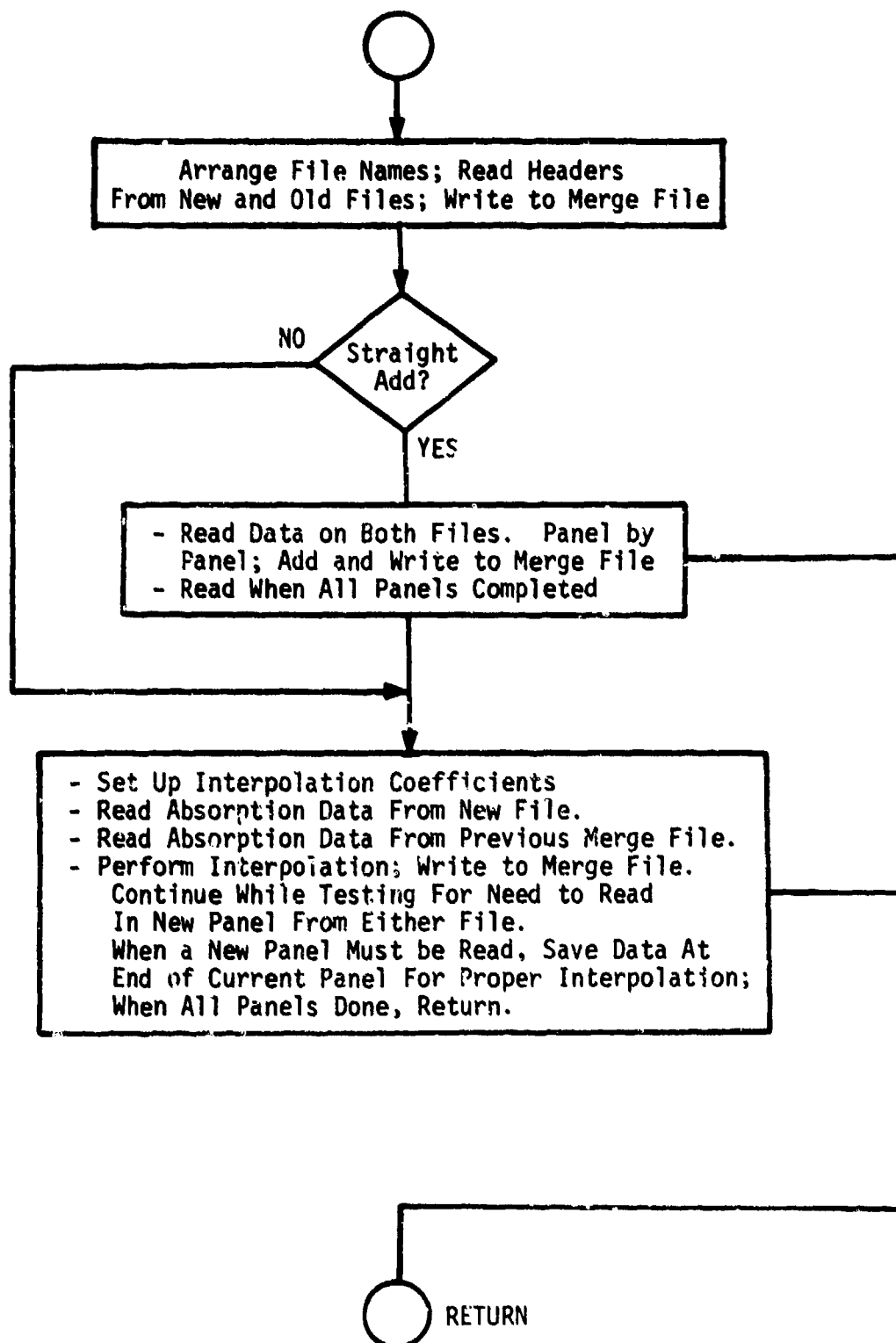


Figure A.5: Flow Diagram for SUBROUTINE ABSMRG.

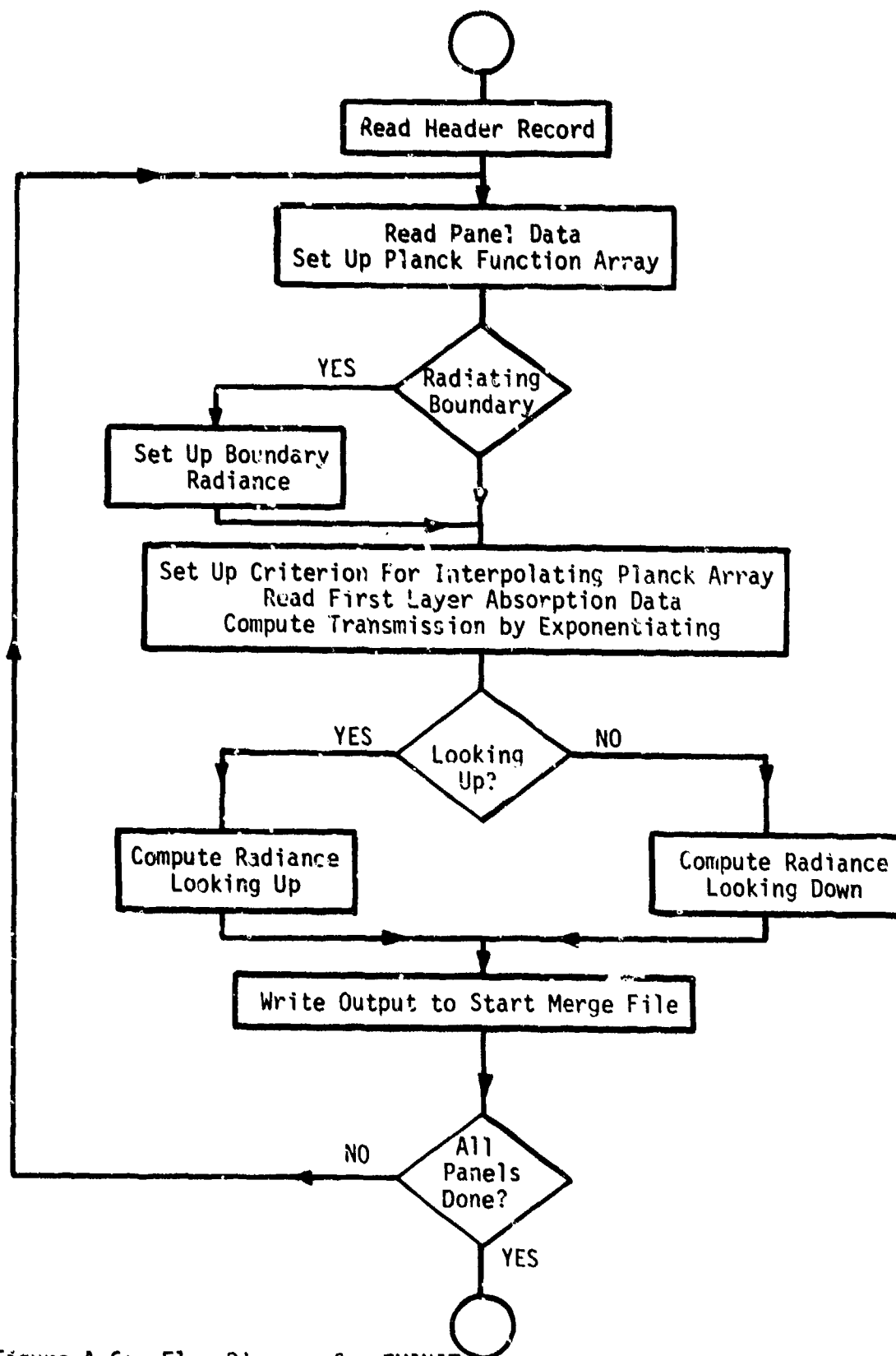


Figure A.6: Flow Diagram for EMINIT

EMUP -- Radiance and Transmittance Looking Up

Subroutine EMUP performs the merging of the radiance and transmission layer-by-layer along a path looking up from ground to space. As in Subroutine ABSMRG, the 1/1 ratio of the DV's (wave number increment) is done separately for speed of computation. For the remaining ratios, ITYPE is computed in FASCODE and equals the value of the numerator of the ratio of the two DV's. The coefficients for the Lagrange four-point interpolation are computed and a file is read which contains the information for the accumulated quantities. This file consists of a header record which includes identification information, the value of the secant, pressure and temperature, concentrations of the absorbing molecules, wave number increment, the value of the first and last wave number in the layer, and a layer count. This is followed by a series of three records per panel. The first record contains the first and last wave number in the panel, the wave number increment and the number of points in the panel. The second record contains the accumulated radiance which is stored in array OLDEM. The third, the accumulated transmission stored in array OLDTR.

Similarly, the file for the new layer contains the header record and first and last wave number record. The next record contains the spectral absorptance from which the transmission is computed and is stored in array TR.

The black body function is computed as described in the text and an interpolation is made for the radiance and transmission with the larger wave number increment. The total radiance along the path length is computed using the formula

$$NEWEM = OLDEM + (1.0 - TR_i) * BB_i * OLDTR$$

where OLDEM is the interpolated old radiance, TR_i the new transmission increment, BB_i , the black body and OLDTR the interpolated transmission. The transmission is computed as

$$NEWTR = OLDTR * TR_i$$

The output file is written such that it can be used as the input when treating the next layer. The flow chart for Subroutine EMUP is in Figure A.7.

EMDOWN -- Radiance and Transmittance Looking Down

Subroutine EMDOWN performs the merging of the radiance and transmission layer-by-layer along a path looking down from space toward ground. However, to achieve efficiency it is arranged such that the calculation always starts at the lowest altitude and continues upward. The logic for EMDOWN is exactly the same as Subroutine EMUP and the formula for computing transmission is the same. The LTE radiance, however, is computed as follows:

$$NEWEM = (1 - TR_i) * BB_i + TR_i * OLDEM$$

where OLDEM is the interpolated old radiance, TR_i the transmission increment of the i 'th layer and BB_i the black body function. In looking from space to ground it is not strictly necessary to compute the total transmission in order to compute the radiance but this feature has been included in this subroutine to make it compatible with Subroutine EMUP. Figure A.7 also gives the flow diagram for this routine.

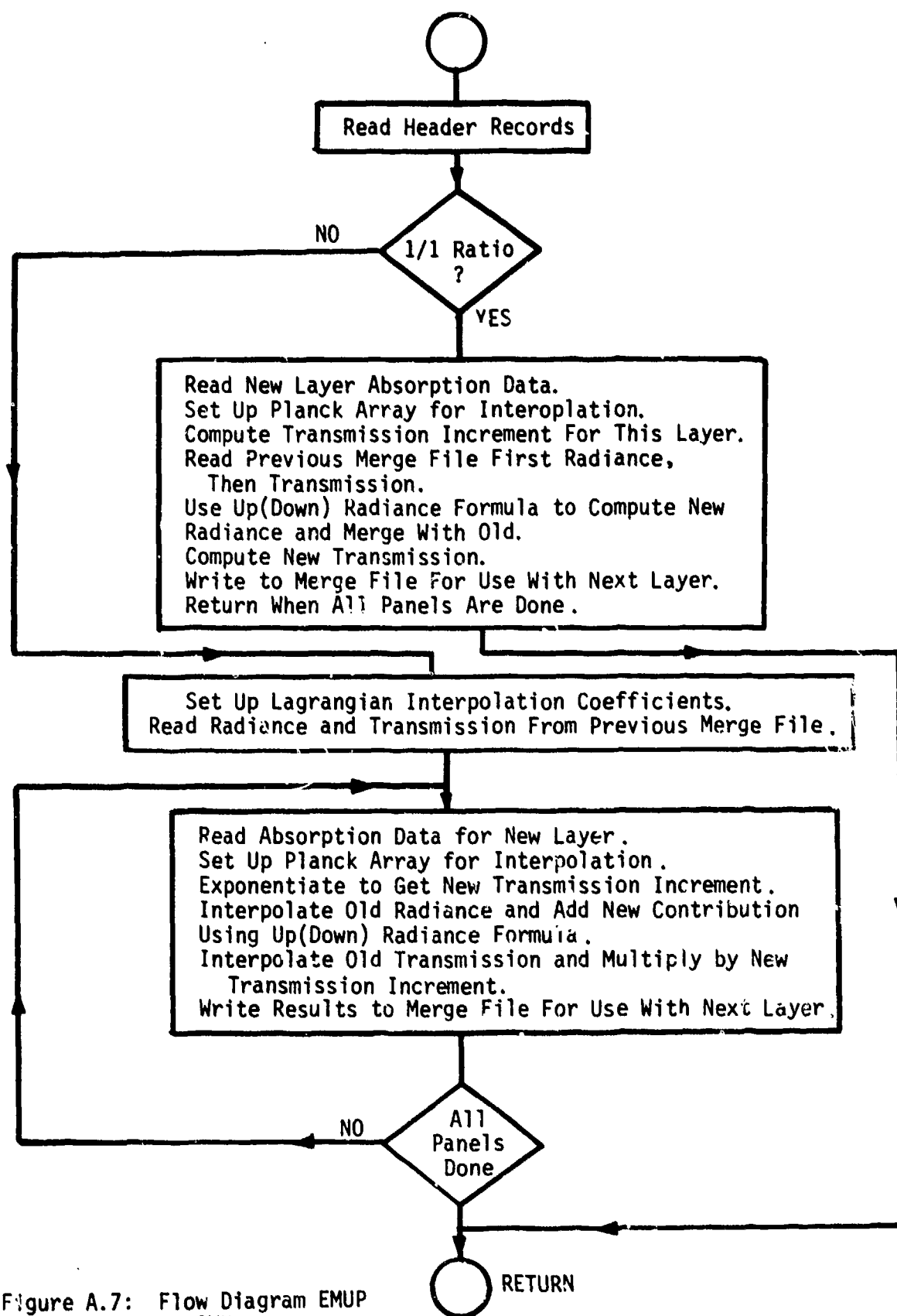


Figure A.7: Flow Diagram EMUP
EMDOWN

APPENDIX B

USER'S GUIDE

Appendix B presents samples of input and output from a run of FASCODE on the AFGL CDC 6600 computer. A user may find these pages helpful in assessing whether the program has been adapted properly to a new machine environment.

As pointed out already, extensive use has been made of the BUFFER IN and BUFFER OUT capability available in CDC FORTRAN Extended. Since other computer systems (such as IBM 360/370) may not have this feature available, we have collected a list of all the BUFFER statements together with their identification numbers. This is given in Table B.1 and should be of assistance to a user whose machine requires the changing of the BUFFER statements to binary READ and WRITE statements.

Table B.2 gives a sample job setup for a run used in developing Test Case Output. The first record contains CDC job control cards (SCOPE). This is followed by a series of Segmentation Loader input cards which determine the way in which FASCODE is to be loaded into the system. The third and final record contains the input data for the execution of the Test Case Problem by FASCODE. Table B.3 contains a list and description of the FASCODE input data. A load map for this run is found in Table B.4. Finally, the output printed by FASCODE in executing this job is presented in Table B.5. To ascertain that a faithful version is in hand, it is recommended that a user execute this test case and compare the output with Table B.5.

With regard to the preparation of model atmospheres for input to FASCODE, the principal requirement is to assure that ratios of the sampling intervals between a layer and the one just above it is less than or equal to 2/1. It is suggested that 3/2 would be a good target ratio. This can be checked by computing the average half-width of the layers using Equations (2.2) or (2.4). If a user would feel more comfortable in his mind that a good model has been derived, one or two extra layers could be added at relatively low cost. However, it should be clear that each new layer increases the running time correspondingly.

TABLE B.1. LOCATION OF BUFFER STATEMENTS

	BUFFER IN(LINFIL,1) (FILMO(1),VLINH1)	001630
	BUFFER IN(LINFIL,1) (FILMO(1),VLINH1)	000790
	BUFFER OUT(KFILE,1) (XID(1),NLAYER)	002540
10	BUFFER IN(LINFIL,1) (VMIN,NREC)	003660
	BUFFER IN(LINFIL,1) (GNU(I1),GNU(I2))	003710
30	BUFFER IN(LINFIL,1) (GNU(I1),MOL(LIMIN))	003750
	BUFFER OUT(KFILE,1) (V1P,NLIM)	005250
	BUFFER OUT(KFILE,1) (FF(NLO),FF(NHI))	005270
	BUFFER IN(KFILE,1) (XID(1),XID(2))	009040
260	BUFFER OUT(MFILE,1) (XID(1),NLAYER)	009060
420	BUFFER IN(LFILE,1) (XID(1),NLAYER)	009080
	BUFFER IN(IOLD,1) (OV1P,NLIMO)	009190
	BUFFER IN(IOLD,1) (DUMF(1),DUMF(NLIMO))	009210
	BUFFER IN(KNEW,1) (V1P,NLIM)	009230
	BUFFER IN(KNEW,1) (FF(1),FF(NLIM))	009250
	BUFFER OUT(MFILE,1) (V1P,NLIM)	009290
	BUFFER OUT(MFILE,1) (FF(1),FF(NLIM))	009310
	BUFFER IN(IOLD,1) (OV1P,NLIMO)	009550
310	BUFFER IN(IOLD,1) (DUMF(1),DUMF(NLIMO))	009580
	BUFFER IN(KNEW,1) (V1P,NLIM)	009620
330	BUFFER IN(KNEW,1) (FF(1),FF(NLIM))	009650
	BUFFER IN(IOLD,1) (OV1P,NLIMO)	009920
	BUFFER IN(IOLD,1) (DUMF(4),DUMF(NLIMO))	009970
150	BUFFER OUT(MFILE,1) (V1P,NLIM)	010170
370	BUFFER OUT(MFILE,1) (FF(1),FF(NLIM))	010190
160	BUFFER IN(KNEW,1) (V1P,NLIM)	010250
350	BUFFER IN(KNEW,1) (FF(1),FF(NLIM))	010260
	BUFFER IN(KFILE,1) (XID(1),NLAYER)	010720
	BUFFER OUT(MFILE,1) (XID(1),NLAYER)	010740
	BUFFER IN(KFILE,1) (OV1P,NLIMO)	011780
	BUFFER IN(KFILE,1) (FF(1),FF(NLIMO))	011790
	BUFFER OUT(MFILE,1) (OV1P,NLIMO)	011360
	BUFFER OUT(MFILE,1) (EMISS(1),EMISS(NLIMO))	011330
	BUFFER OUT(MFILE,1) (FF(1),FF(NLIMO))	011400
	BUFFER IN(LFILE,1) (XID(1),XID(2))	011780
	BUFFER IN(KFILE,1) (XID(1),NLAYER)	011800
	BUFFER OUT(MFILE,1) (XID(1),NLAYER)	011820
435	BUFFER IN(LFILE,1) (OV1P,NLIMO)	011950
	BUFFER IN(LFILE,1) (OLDEM(1),OLDEM(NLIMO))	011970
	BUFFER IN(LFILE,1) (OLDTR(1),OLDTR(NLIMO))	011990
	BUFFER IN(LFILE,1) (OV1P,NLIMO)	012420
	BUFFER IN(LFILE,1) (OLDEM(1),OLDEM(NLIMO))	012480
	BUFFER IN(LFILE,1) (OLDTR(1),OLDTR(NLIMO))	012530
	BUFFER IN(LFILE,1) (OV1P,NLIMO)	013160
	BUFFER IN(LFILE,1) (OLDEM(4),OLDEM(NLIMO))	013100
130	BUFFER IN(LFILE,1) (OLDTR(4),OLDTR(NLIMO))	013130
150	BUFFER OUT(MFILE,1) (V1P,NLIM)	013420
	BUFFER OUT(MFILE,1) (NEWEM(1),NEWEM(NLIM))	013440
	BUFFER OUT(MFILE,1) (NEWTR(1),NEWTR(NLIM))	013460
360	BUFFER IN(KFILE,1) (V1P,NLIM)	013630
	BUFFER IN(KFILE,1) (TR(1),TR(NLIM))	013650
	BUFFER IN(LFILE,1) (XID(1),XID(2))	014570
	BUFFER IN(KFILE,1) (XID(1),NLAYER)	014590
	BUFFER OUT(MFILE,1) (XID(1),NLAYER)	014610
535	BUFFER IN(LFILE,1) (OV1P,NLIMO)	014740
	BUFFER IN(LFILE,1) (OLDEM(1),OLDEM(NLIMO))	014760
	BUFFER IN(LFILE,1) (OLDTR(1),OLDTR(NLIMO))	014780
	BUFFER IN(LFILE,1) (OV1P,NLIMO)	015220
480	BUFFER IN(LFILE,1) (OLDEM(1),OLDEM(NLIMO))	015280
	BUFFER IN(LFILE,1) (OLDTR(1),OLDTR(NLIMO))	015300
	BUFFER IN(LFILE,1) (OV1P,NLIMO)	015800
	BUFFER IN(LFILE,1) (OLDEM(4),OLDEM(NLIMO))	015840
42	BUFFER IN(LFILE,1) (OLDTR(4),OLDTR(NLIMO))	015860
150	BUFFER OUT(MFILE,1) (V1P,NLIM)	016150
	BUFFER OUT(MFILE,1) (NEWEM(1),NEWEM(NLIM))	016170
	BUFFER OUT(MFILE,1) (NEWTR(1),NEWTR(NLIM))	016190
360	BUFFER IN(KFILE,1) (V1P,NLIM)	016390
	BUFFER IN(KFILE,1) (TR(1),TR(NLIM))	016410

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TABLE B.2. SAMPLE RUN DECK FOR TEST PROBLEM

```

74/74   OPT=1                               FTN 4.6+425       13/14/79   16.43.20

CLOUGH,CM57700,T48.          FASCODEL          2  4   CLOUGH
ATTACH,TAPE3,CLOU199JTO2210,IO=CLOUGH,MP=1.
REQUEST,TAPE12,*PF.
ATTACH,HIRACL,IO=CLOUGH,MR=1.
FTN,I=HIRACL,SL,B=LGO.
ATTACH,HIRACD,IO=CLOUGH,MP=1.
FTN,I=HIRACD,SL,B=OGO.
ATTACH,VGO,FASCODE,IO=CLOUGH,MR=1.
REWIND,OUTPUT.
MAP,PART.
LOSET,PRESET=INDEF.
LCAC,VGO.
LOAD,LGO.
LOAC,OGO.
SEGLOAD.
EXECUTE,FASCODE.

EOR
FAST TREE FASCODE=(HIRACV,HIRACL,HIRACD,APSMRG,ENINIT,ENUF,EMOONN)
FASCODE GLOBAL MAIN,NEW
HIRACV INCLUDE SHAPEL,SHAPE,VOICON,RDFILE,CONVFNV,PANEL,MOLEC,QVRFAC
HIRACL INCLUDE SHAPEL,RDFILE,CONVFNL,PANEL,MOLEC,QVRFAC
HIRACD INCLUDE SHAPE,ROFILE,CONVFNC,PANEL,MOLEC,QVRFAC
END FASCODE

EOR
1 APPROX TO KYLE REPORT....MIDLATITUDE SUMMER
  1    1    0    0    0
  1.
  2595.    2105.
  273.
  10
  525.8566  264.3769          4.00 KM TO    7.00 KM
  9.380E+21  1.409E+21  2.611E+17  1.195E+18  3.201E+17  5.831E+18  8.942E+23  3.334E+24
  332.8741  242.7476          7.00 KM TO    11.00 KM
  1.849E+21  1.284E+21  4.587E+17  1.089E+18  2.917E+17  5.724E+18  8.149E+23  3.037E+24
  197.5644  222.8735          11.00 KM TO   14.00 KM
  6.815E+19  6.262E+20  5.351E+17  5.313E+17  1.423E+17  3.035E+18  3.975E+23  1.482E+24
  124.0700  216.0000          14.00 KM TO   17.00 KM
  7.612E+19  4.043E+20  7.852E+17  3.429E+17  9.185E+16  1.966E+18  2.566E+23  9.543E+23
  77.2771  216.9193          17.00 KM TO   20.00 KM
  5.045E+18  2.509E+20  1.091E+18  2.129E+17  5.702E+16  1.216E+18  1.593E+23  5.936E+23
  36.6033  223.8896          20.00 KM TO   30.00 KM
  1.349E+19  3.284E+20  3.311E+18  2.786E+17  7.462E+16  1.592E+18  2.085E+23  7.771E+23
  8.3402  242.9639          30.00 KM TO   40.00 KM
  4.989E+18  7.057E+19  1.259E+18  5.942E+16  1.603E+16  3.419E+17  4.477E+22  1.661E+23
  2.4509  267.2770          40.00 KM TO   45.00 KM
  4.913E+17  1.111E+19  1.523E+17  9.484E+15  2.541E+15  5.425E+16  7.097E+21  2.645E+22
  1.1559  267.2521          45.00 KM TO   54.00 KM
  2.590E+17  8.437E+18  5.597E+16  7.156E+15  1.917E+15  4.090E+16  5.355E+21  1.996E+22
  .2742  255.4215          54.00 KM TO  100.00 KM
  4.745E+18  4.040E  18  1.175E  16  3.464E  15  9.276E  14  1.979E  16  2.591E  21  9.649E  21

```

TABLE B.3. INPUT DATA DESCRIPTION

XID	7 element array containint text. The text is printed with FASCODE output and is used as a header for execution time plots.
IHIRAC	1, Voigt approximation to line shape 2, Lorentz approximation to line shape 3, Doppler approximation to line shape
IEMIT	0, no emission calculation 1, emission calculation performed
ILOOK	0, emission calculation from ground to space 1, emission calculation from space to ground
IPLLOT	0, no plot 1, on-line plot 2, off-line plot 3, CRT plot 4, graphics plot
ISCAN	indicates parameter to be plotted (use if IPLOT#0) 1, absorption coefficient $YY=YY$ 2, log of absorption coefficient $YY=ALOG10(YY)$ 3, transmission $YY=\exp(-YY)$
SECANT	secant of the angle between the line-of-sight and the zenith
V1 (lower limit) V2 (upper limit)	specify the wave number range for the output data (cm^{-1});

TABLE B.3. INPUT DATA DESCRIPTION (continued)

TBOUND temperature ($^{\circ}\text{K}$) used to compute a boundary.
 If TBOUND=0, no boundary is computed (currently
 used for looking down)

NNLAYR number layers + 1

P_AVE average pressure (mb) for the layer

TAVE average temperature ($^{\circ}\text{K}$) for the layer

WK array containing the molecular column densities
 for the layer ($\text{molecules}/\text{cm}^2$)
 H_2O , CO_2 , O_3 , N_2O , CO , CH_4 , O_2

IF IPLOT=1

PLOTID 3 element array containing 30 characters of text
 used as a beginning and ending banner on pen plots

V1 the range of wave numbers over which plot will
 V2 be made (cm^{-1})

XSIZE size of X axis (in)

DX number of units of X per inch

YMIN range of Y-axis
 YMAX

WWSC the constant k in the expression $y=e^{-ky}$

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TABLE B.4. LOAD MAP

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TABLE B.4. LOAD MAP (continued)

[illegible]

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TABLE 8.4. LOAD MAP (continued)

[illegible]

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TABLE B.4. LOAD MAP (continued)

NAME	TYPE	START	END	LENGTH	ADDRESS
CLSV.S0	PROGRAM	00000000	00000000	00000000	00000000
ERR.RK	PROGRAM	00000000	00000000	00000000	00000000
MODF.RM	PROGRAM	00000000	00000000	00000000	00000000
MCT.00	PROGRAM	00000000	00000000	00000000	00000000
OPFX.S0	PROGRAM	00000000	00000000	00000000	00000000
CID.PM	PROGRAM	00000000	00000000	00000000	00000000
CLSF.S0	PROGRAM	00000000	00000000	00000000	00000000
DSJA.RM	PROGRAM	00000000	00000000	00000000	00000000
WAR.S0	PROGRAM	00000000	00000000	00000000	00000000
FSD.S0	PROGRAM	00000000	00000000	00000000	00000000
SKSF.S0	PROGRAM	00000000	00000000	00000000	00000000
RLC.PM	PROGRAM	00000000	00000000	00000000	00000000
SYS.00	COMMON	00000000	00000000	00000000	00000000
PUT.00	COMMON	00000000	00000000	00000000	00000000
SKSF.F0	COMMON	00000000	00000000	00000000	00000000
SKS8.F0	COMMON	00000000	00000000	00000000	00000000
SK9L.F0	COMMON	00000000	00000000	00000000	00000000
CLSY.F0	COMMON	00000000	00000000	00000000	00000000
GET.00	COMMON	00000000	00000000	00000000	00000000
REA.F0	COMMON	00000000	00000000	00000000	00000000
GET.F0	COMMON	00000000	00000000	00000000	00000000
GET.00	COMMON	00000000	00000000	00000000	00000000
QPE5.F0	COMMON	00000000	00000000	00000000	00000000
MEMC.P0	COMMON	00000000	00000000	00000000	00000000
OP2M.F0	COMMON	00000000	00000000	00000000	00000000
CLSF.F0	COMMON	00000000	00000000	00000000	00000000
JMPS.PM	COMMON	00000000	00000000	00000000	00000000
PUT.F0	COMMON	00000000	00000000	00000000	00000000
CON.00	COMMON	00000000	00000000	00000000	00000000
AB9.RM	COMMON	00000000	00000000	00000000	00000000
TERM.RM	COMMON	00000000	00000000	00000000	00000000
STP.END	COMMON	00000000	00000000	00000000	00000000
Q8.10	COMMON	00000000	00000000	00000000	00000000
FCL.C.	COMMON	00000000	00000000	00000000	00000000
AUF.H0	COMMON	00000000	00000000	00000000	00000000
NEW	GLOBAL	00000000	00000000	00000000	00000000
MAIN	GLOBAL	00000000	00000000	00000000	00000000

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TABLE B.4. LOAD MAP (continued)

[illegible]

TABLE B.4. LOAD MAP (continued)

```

>>>>>>> SEGMENT EINIT FMA = +030524 EXEC.FMA= +030504 LMA+1= +031124
*** BLOCK NAME..TYPE.....FMA.....LENGTH
EINIT PROGRAM +030524 J000414
OPAL COMMON +031120 J000004
*** FN,GLOBAL..SEGMENT...SAFETY.....FMA
NEW FASCODE SAFE +030443
MAIN FASCODE SAFE +030510

>>>>>>> SEGMENT EIMP FMA = +030504 EXEC.FMA= +030504 LMA+1= +037025
*** BLOCK NAME..TYPE.....FMA.....LENGTH
EIMP PROGRAM +030504 J006254
MPAL COMMON +036763 J000004
OPAL COMMON +036764 J000004
XEMISS COMMON +036770 J000035
*** FN,GLOBAL..SEGMENT...SAFETY.....FMA
MAIN FASCODE SAFE +030504

>>>>>>> SEGMENT EMOJWH FMA = +030504 EXEC.FMA= +030504 LMA+1= +037027
*** BLOCK NAME..TYPE.....FMA.....LENGTH
EMOJWH PROGRAM +030504 J006256
MPAL COMMON +036762 J000004
OPAL COMMON +036766 J000004
XEMISS COMMON +036772 J000035
*** FN,GLOBAL..SEGMENT...SAFETY.....FMA
MAIN FASCODE SAFE +030500
***** CM BLANK COMMON FMA= +037727 LMA+1= J05125

```

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TABLE B.5. TEST CASE OUTPUT

03/29/79 16.24.35.

1 APPROX TO KYLE REPORT....MIDLATITUDE SUMMER
1 1 0 0
SECANT = 1.0000000
IMIRAC = 1
V1 V2 2655. 2185.
TBOUND 273.

1 LINE FILE FOR THE FASTCODE REPORT

H2O = 1
CO2 = 1
O3 = 1
N2O = 1
CO = 1
CH4 = 1
O2 = 1

LOWEST LINE = 1990.000 HIGHEST LINE = 2210.000

MLAYER 1
FIRST DV = .013750 0272.
.0138 -1

VOIGT

1 APPROX TO KYLE REPORT....MIDLATITUDE SUMMER
OUTPUT FILE NO. = 10
SECANT = 1.00000
PRESS(MR) = 525.05660
TEMP(K) = 264.30

COLUMN DENSITY(MOLECULES/CM**2)

H2O = 9.380E+21
CO2 = 1.449E+21
O3 = 2.611E+17
N2O = 1.195E+18
CO = 3.201E+17
CH4 = 6.031E+16
O2 = 8.542E+23

RV(CM-1) = .0130000
V1(CM-1) = 2395.0000
V2(CM-1) = 2105.0000
ROUNDVS(CM-1) = 3.532A

TIME 5.952
READ .314
CONVOLUTION .700
PANEL .005

TABLE B.5. TEST CASE OUTPUT (continued)

PLATE 2

VOIGT	APPROX TO	KYLF REPORTMID	ATTITUDE	SUMMER	EMISS UP

OUTPUT FILE NO. = 16

1.00000

09233(MB) = 332.87410

TEMP(K) = 242.75

COL. UNIT OF MS ITV (MOLECULES/CM²)
$$M20 = 1.649E+21$$

CO2 • 1.2A4E+21

03 - 605,7E+17

02N 36 90 18

$$CO = 2.917E+17$$

CM4 = 5.224E+10

DocId: 3429668

1000-5402 (1-800) 285-0000

W2 (CM-1) = 2135.1032

2.3552

TIME	READ	CONVOLUTION	PANFL
5.035	.026	.616	.611

AVERAGE WIDTH =	.03256	AVERAGE ZETA =	.94373	NO. LINES =	426	NO. CHANGES =	0
<p>  </p>							

TIME TIME AT THE START OF FMIP IS 6.842

THIS OUTPUT IS WRITTEN ON FILE 12

PH. 0606606656667

PAGE 00000000000000000000

1 2095.00000 .12745475E-07 .06547116E+3)

1000 2105.303400 .160220952-08 .98307010E+10

TIME AT THE END OF EMPD IS 6.954
.112 SECS WERE REQUIRED FOR THIS ADDITION

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TABLE B.5. TEST CASE OUTPUT (continued)

MLAYER 3
FIRST NV = .005457652914983
COMPUTED NV BEFORE MODIFICATION = .005657652914983
.00613333333333 2

VOIGT
1 APPROX TO KYLE REPORT...MILLATITUDE SUMMER MISS UP

OUTPUT FILE NO. = 10

SECANT = 1.00000

PRESS(MB) = 197.56440

TEMP(K) = 222.87

COLUMN DENSITY (MOLECULES/CM**2)

H2O = 6.815E+19
CO2 = 6.262E+20
O3 = 5.151E+17
N2O = 5.313E+17
CO = 1.423E+17
CH4 = 3.035E+18
O2 = 3.975E+23

NV(CH-1) = .00613333

V1(CH-1) = 2095.0000

V2(CH-1) = 2105.0000

ROUNDVS(CM-1) = 1.5701

TIME READ CONVOLUTION PANEL
7.633 .026 .493 .030
AVERAGE WIDTH = .0280 AVERAGE 7ETA = .91514 NO. LINES = 701 NO. CHANGES =

ENUP, MFILE, LFILE, KFILE 11 12 10

7.630

THE TIME AT THE START OF ENUP IS

THIS OUTPUT IS WRITTEN ON FILE 11

P = .6666666666667

P = .3333333333333

1 2095.00000 .13365235E-07 .82352182E+00

1400 2103.629600 .32451155E-08 .95188694E+17

1 2103.535733 .30887121E-08 .95452910E+00

223 2104.097333 .1745714E-08 .97130757E+00

THE TIME AT THE END OF ENUP IS 7.791

.153 SECS WERE REQUIRED FOR THIS ADDITION

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TABLE B.5. TEST CASE OUTPUT (continued)

WEAVER A
FIRST DV = .003840652658061
COMPUTED BY BEFORE MODIFICATION = .00364652658001
.003366666666667 1

VOIGT
1 APPROX TO KYLE REPORT.....MIDWINTER SUMMER MISS UP

OUTPUT FILE NO. = 13

SECANT = 1.00000

PRESS(MB) = 124.30000

TEMP(K) = 216.00

COLUMN DENSITY (MOLECULES/CM**2)

H2O = 7.612E+18
CO2 = 4.643E+28
O3 = 7.852E+17
N2O = 3.429E+17
CO = 9.145E+16
CH4 = 1.960E+18
O2 = 2.568E+23

DV(CM-1) = .00306667

V1(CM-1) = 2095.680

V2(CM-1) = 2105.800

ROUNDOFF(CM-1) = .7851

TIME READ CONVOLUTION PANEL
8.449 .017 .040 .044

AVERAGE WIDTH = .01311 AVERAGE ZETA = .87572 NO. LINES = 554 NO. CHANNELS = 4

EMUP, MFILE, LFILE, RFILE 12 11 10
THE TIME AT THE START OF EMUP IS 9.456
THIS OUTPUT IS WRITTEN ON FILE 12
P = .5

1 2095.00000 .14056810E-07 .75072151E+00
1400 2099.31600 .76514047E-08 .89597990E+03
1 2899.31700 .73954920E-08 .89964745E+04
1054 2105.06000 .13737055E-08 .95772057E+10

THE TIME AT THE END OF EMUP IS 8.739
.203 SECS WERE REQUIRED FOR THIS ADDITION

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TABLE B.5. TEST CASE OUTPUT (continued)

MEASUR 6
FIRST CV = .00121949884323
COMPUTED BY BEFORE MODIFICATION = .P0121949884323
.00115 1

VOIGT APPROX TO KYLE REPORT....HIGHER ALTITUDE SUMMER ENTISS W

OUTPUT FILE NO. = 11

SECANT = 1.00000

PRESS(MR) = 34.62330

TEMP(K) = 223.89

COLUMN DENSITY(MOLECULES/CM**2)

M20 = 1.349E+19
C02 = 3.204E+28
O3 = 3.311E+19
M20 = 2.776E+17
CO = 7.462E+16
CH4 = 1.592E+18
N2 = 2.885E+23

DV(CM-1) = .00115000

V(CM-1) = 2995.6802

V2(CM-1) = 2175.6622

BOUNDVS(CM-1) = .2944

TIME READ CONVOLUTION CHANNEL
18.367 .16 .303 .131
AVERAGE WIDTH = .38459 AVERAGE ZETA = .67584 NO. LINES = 457 NO. CHARGES =

THE TIME AT THE START OF EMUP IS 17.375
THIS OUTPUT IS WRITTEN ON FILE 12
P = .5

1 2095.87200 .2176524E+07 .2165454E+03
1404 2195.514058 .2777282E+08 .0945792E+08
1 2096.519200 .3775674E+08 .0941879E+08
240 2099.374058 .1241384E+07 .3493245E+07
1 2099.374283 .1335822E+07 .2436317E+07
240 2102.179800 .1937533E+08 .9443663E+07
1 2102.179200 .1947793E+08 .9437461E+07
240 2104.893558 .5664301E+08 .6563372E+07
1 2104.899210 .5144762E+08 .7173427E+07
89 2105.886438 .2532691E+08 .9457852E+07

THE TIME AT THE END OF EMUP IS 11.002
.789 SPCS WERE REQUIRED FOR THIS ADDITION

TABLE B.5. TEST CASE OUTPUT (continued)

MLA 9.7
FIRST DV = .26615162275801
COMPUTED ON BEFORE MODIFICATION = .038615162275801
.880575 1

1 APPROX TO KYLE REPORT.....PION.ATIUD. SUMMER
VOICET
FRISS UP

OUTPUT FILE NO. = 18

SECANT = 1.00689

PRESS(MR) = 8.34620

TEMP(M) = 242.96

COLUMN DENSITY(MOLECULFS/CM**2)

H2O = 4.909E+18
CO2 = 7.353E+19
O3 = 1.259E+18
N2O = 5.992E+16
CN = 1.603E+16
CH4 = 3.419E+17
O2 = 4.477E+22

OVICM-1) = .08657500

V1(CM-1) = 2995.0030

V2(CM-1) = 2185.0000

BOUNDVS(CM-1) = .1472

TIME
11.012 READ CONVOLUTION
.818 .369
PANEL
.267

AVERAGE WIDTH = .37229 AVERAGE ZETA = .31237 NO. LINES = 476 NO. CHANGES = J
EMUP, WFILE, LFILE, KFILE 11 12 10

TIME TIME AT THE START OF EMUP IS 11.018
THIS OUTPUT IS WRITTEN ON FILE 11
P = .5

1 2095.003000 .27902461E-07 .00214101E-01
1484 2095.009825 .21160866E-08 .96931811E+11
1 2695.039600 .21152274E-08 .96931811E+11
2403 2697.189025 .14366699E-07 .83259677E+11
1 2897.189600 .14461886E-07 .8314412E+11
2400 2098.569025 .44750552E-08 .97183516E+11
1 2898.569600 .44968103E-08 .93334341E+11
2400 2899.949825 .13551865E-07 .43647145E+11
1 2899.949600 .1294471E-07 .46983639E+11
2400 2181.329825 .37535367E-06 .92444192E+11
1 2131.329600 .37532367E-06 .92442002E+11

TABLE B.5. TEST CASE OUTPUT (continued)

2430 2102.709025 .2102709025 .355942965+21
1 2102.709025 .2102709025 .956491426+11
2403 2104.009025 .209967445-00 .911940528+11
1 2104.009025 .20814157E-00 .93712390E+11
1504 2104.999025 .27301751E-00 .90846106E+11

THE TIME AT THE END OF FMP IS 13.194
1.378 SECS WERE REQUIRED FOR THIS ADDITION

MLAYER A
FIRST DV = .905429977640457
COMPUTED DV BEFORE MODIFICATION = .935429977640457
.100575 0

VOICZ
1 APPROX TO KYLE REPORT.....MOL ATITUDE SUMMER MISS JP

OUTPUT FILE NO. = 10
SECANT = 1.30030
PRESS(MB) = 2.55090
TEMP(K) = 261.20

COLUMN DENSITY (MOLECULES/CM**2)

H2O = 4.913E+17
CO2 = 1.11E+19
O3 = 1.529E+17
N2O = 9.404E+15
CO = 2.541E+15
CH4 = 5.420E+16
O2 = 7.697E+21

OV(CM-1) = .00557500
V1(CM-1) = 2095.0000
V2(CM-1) = 2105.0000
BOMMVS(CM-1) = .1472

TIME READ CONVOLUTION PANEL
13.075 .027 .310 .235

AVERAGE WIDTH = .20202 AVERAGE ZETA = .11532 NO. LINES = 427 NO. CHANGES = 3
CMUP, WFILE, LFILE, WFILE 12 11 10

THE TIME AT THE START OF EMIP IS 13.070
THIS OUTPUT IS WRITTEN ON FILE 12
1 2095.000000 .29295767E-07 .65129594E-11
1408 2095.009025 .21165715E-00 .96901773E+00
1 2095.009025 .21152700E-00 .96902175E+11

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TABLE B.5. TEST CASE OUTPUT (continued)

2460 2497.183625 .14371856F-J7 .02756112E+00
1 2897.189628 .14465357E-07 .23180742E+00
2480 2898.569825 .44772031E-08 .03381706F+01
1 2498.569630 .44961704E-08 .03332956E+00
2480 2099.949825 .13654558E-07 .63556150F+10
1 2899.949688 .13886087E-07 .46985485E+10
2480 2181.329425 .37551172E-08 .92866121E+00
1 2181.329480 .37582693E-08 .92397671E+00
2400 2182.719825 .2303896E-08 .56893654E+00
1 2182.789688 .23131865E-08 .95687406E+00
2400 2184.089825 .29252031E-08 .9617242E+00
1 2184.089608 .29256746E-08 .9692761E+00
1584 2184.999825 .27471885E-08 .90825120E+00

THE TIME AT THE END OF EMUP IS 14.686
.010 SECS WERE REQUIRED FOR THIS ADDITION

MLAYER 9
FIRST DV = .889275838798483
COMPUTED DV BEFORE MODIFICATION = .6985275931798433
.838575 8

1 APPROX TO KYLE REPORT...MID-ALTITUDE SIMMER

OUTPUT FILE NO. = 18

SECANT = 1.00000

PRESS(M9) = 1.15590

TEMP(K) = 267.25

COLUMN DENSITY(MOLECULES/CM**2)

N2O = 2.598E+17
CO2 = 8.437E+18
O3 = 6.597E+16
N2O = 7.156E+15
CO = 1.917E+15
CH4 = 4.090E+16
O2 = 5.355E+21

DV(ICM-1) = .05637590

V1(ICM-1) = 2895.0000

V2(ICM-1) = 2185.0000

BOUNDARY(CM-1) = .1472

TIME 15.361
PEAK .017
CONVOLUTION .312
PANEL .293

TABLE B.6. TEST CASE OUTPUT (continued)

AVERAGE WIDTH = .28196 AVERAGE ZETA = .15524 NO. LINES = 13. NO. CHARGES = 1

THE TIME AT THE START OF ENUP IS 15.165

TIME OUTPUT IS WRITTEN ON FILE 11

1 2095.00000 .290419315-17 .04565700E-11
1400 2095.00000 .21169594E-10 .96961753E+11
1 2095.00000 .71133040E-08 .9602257E+09
2400 2097.109025 .1637161E-07 .07255545E+14
1 2037.10900 .14062224E-07 .07100115E+03
2400 2098.50000 .6670712E-08 .93301433E+03
1 2098.50000 .6670712E-08 .93301433E+03
2400 2099.949025 .13670095E-07 .47540242E+14
1 2499.94900 .13186533E-17 .4685005E+10
2400 2101.329025 .37564435E-20 .92479193E+08
1 2101.32900 .37564435E-20 .92479193E+08
2400 2102.769025 .23097452E-06 .95693327E+17
1 2102.76900 .2314523E-06 .95693327E+17
2400 2104.00000 .29312077E-08 .96160967E+08
1 2104.00000 .29312077E-08 .96160967E+08
1504 2104.999025 .27911753E-08 .96822146E+10

THE TIME AT THE END OF ENUP IS 16.186
.021 SECS WERE REQUIRED FOR THIS ADDITION

LAYER 10

FIRST DV = .820594539321603

COMPUTED BY BEFORE MODIFICATION = .0005045393216063
.000575 8

VOIGT

1 APPROX TO KYLE REPORT.....MIDL ATTITUDE SUMMER LAST LAYER EMISS UP

OUTPUT FILE NO. = 10

SECANT = 1.30000

PRESS(M) = .27420

TEMP(K) = 255.42

COLUMN DENSITY(MOLECULES/CM**2)

H2O = 4.745E+16
CO2 = 4.300E+16
O3 = 1.176E+16
N2O = 3.464E+15
CO = 9.276E+14
CH4 = 1.579E+16
O2 = 2.591E+21

DVICH-11 = .00057504

TABLE B.5. TEST CASE OUTPUT (continued)

Y1(CH-1) = 2095.0000
Y2(CH-1) = 2105.0000
BOUNDVS(CH-1) = .1472

TIME	READ	COMPUTATION	PANEL	NO. LINES	NO. CHANGES
16.036	.017	.327	.226	430	8

AVERAGE WIDTH = .38107 AVERAGE ZETA = .01435
EMUP, 4FILE, LFILE, RFILE 12 11 10

THE TIME AT THE START OF EMUP IS 16.036
THIS OUTPUT IS WRITTEN ON FILE 12

1	2095.00000	.29914361E-07	.63689560E-01
1400	2095.00000	.21160607E-06	.96961752E+00
1	2095.00000	.21153860E-06	.96962655E+01
2400	2097.109025	.14717151E-07	.03255475E+00
1	2097.109025	.14466249E-07	.03100040E+00
2400	2098.569025	.44782049E-08	.93381414E+01
1	2098.569025	.44969950E-08	.92332173E+00
2400	2099.949025	.13875607E-07	.4539277E+01
1	2099.949025	.13107105E-07	.46490136E+01
2400	2101.329025	.37564752E-06	.52479157E+01
1	2101.329025	.37594080E-06	.52396753E+01
2400	2102.709025	.23897551E-06	.95693316E+01
1	2102.709025	.23143379E-06	.95647671E+01
2400	2104.089025	.29313654E-06	.91168769E+01
1	2104.089025	.28310741E-06	.90688706E+01
1500	2106.999025	.27512833E-06	.91022610E+01

THE TIME AT THE END OF EMUP IS 17.654
.915 SECS WERE REQUIRED FOR THIS ADDITION

USAGE NOTES

1. The user must structure the input atmosphere such that the ratio of the previous DV to the present DV is acceptable to FASCODE, (see the sample input data).
2. The program is written for execution on a CDC 6600 computer system at Hanscom AFB. Accordingly, the control cards input/output statements and plot options need to be tailored to the user's installation.

APPE' . . .

PROGRAM LISTING

LISTING OF FASCODE PROGRAM

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PROGRAM FASCODE      74/74    OPT=1                      FTM 4.6+428      03/14/78

1      PROGRAM FASCODE(INPUT=133/1300,OUTPUT=4130/1300,TAPES=INPUT
      C ,TAPE6=OUTPUT,TAPE7, TAPE10,TAPE11 ,TAPE12)
      C
      C FAST SIGNATURE CODE
      C
      C COMMON CONST(250,9)
      C COMMON FF(7600),SF(900),VSF(225)
      C COMMON/PAIN/ KFILE,KPANEL,P0,TEMPO
      C COMMON/NEW/  NMOL,XID(7),SECANT,PAVE,TAVE,MHOLID(7),WK(7),
10      C          DV,V1,V2,NLAYER
      C COMMON /BUFMD/ FILMD(10),MHOLID(10),MOLIND(10),VLINLO,VLINHI
      C
      NMOL=7
      ITYPE=-1
15      P0=1013.
      TEMPO=296.
      KPANEL=0
      LINFIL=7
      MFILE=12
20      LFILE=11
      KFILE=10
      NLAYER=0
      PRINT 900
      READ 910,(XID(I),I=1,7)
25      C
      C IHIRAC = 1 CALL IHIRACV
      C IHIRAC = 2 CALL IHIRACL
      C IHIRAC = 3 CALL IHIRACH
      C
30      C IF IEMIT .EQ. 1  PROGRAM WILL COMPUTE EMISSION.
      C
      C ILOOK=1  LOOKING FROM SPACE TO GROUND FOR EMISSION
      C ILOOK=0  LOOKING FROM GROUND TO SPACE FOR EMISSION
      C
35      READ 920, IHIRAC,IEMIT,ILOOK,ISCAN,IPLOT
      IF (IEMIT.EQ.0) XID(7)=10M AFS COEFF
      IF ( (IEMIT.EQ.1) .AND. (ILOOK.EQ.0) ) XID(7)=10M EMISS UP
      IF ( (IEMIT.EQ.1) .AND. (ILOOK.EQ.1) ) XID(7)=10M EMISS DWN
      PRINT 930, XID
40      PRINT 920, IHIRAC,IEMIT,ILOOK,ISCAN,IPLOT
      READ 940,SECANT
      PRINT 950,SECANT
      PRINT*, "IHIRAC = ",IHIRAC
      C
45      C TBOUND IS A TEMPERATURE WHICH WILL BE USED TO COMPUTE A
      C BOUNDARY. WHEN TBOUND = 0, NO BOUNDARY WILL BE USED.
      C
      READ 960, V1,V2
      PRINT *, " V1 , V2  " , V1,V2
50      READ 960, TBOUND
      PRINT *, " TBOUND  " , TBOUND
      C
      READ 970,NLAYER
      BUFFER IN(LINFIL,1) (FILMD(1),VLINHI)
55      IF (UNIT(LINFIL).EQ.0) STOP
      PRINT 970, FILMD
      PRINT 905
      PRINT 980, (MHOLID(I),MOLIND(I),I=1,NMOL)
      PRINT 970, VLINLO,VLINHI
      IF (2*(NLAYER/2).NE. NLAYER) GO TO 110
      MSTOP=MFILE
      MFILE=LFILE
      LFILE=MSSTOP
60      CONTINUE
      IF (IEMIT.EQ.0) KFILE=MFILE
      DO 280 K=1,NLAYER
      PRINT 900
      ISWALL=0
      REWIND LINFIL
70      BUFFER IN (LINFIL,1) (FILMD(1),VLINHI)
      IF (UNIT(LINFIL) .EQ. 0 ) STOP
      NLAYER=NLAYER+1
      PRINT *, " NLAYER = ", NLAYER
      IF (K.EQ.NLAYER) XID(8)=10MLAST LAYER

```

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PROGRAM	PASCODE	P4/P4	OPT=1	PYN 4.0-420	03/10/70
75		READ Q40,PAVE,TAVE			000040
		READ Q40,(MK(IK),IK=1,7)			000050
120		OLDV=OV			000060
		DENSOP=PAVE/PS*SORT(TEMP0/TAVE)			000070
		ALBAR=(0.10)*DENSOP			000080
80		AVMASS=JL			000090
		ADBAR=0.50170E-07*(0.5*(V1+V2))*SORT(TAVE/AVMASS)			000100
		AVBAR=0.5*(ALBAR + SORT (ALBAR*ALBAR + 4.*ADBAR*ADBAR))			000110
		IF (IMIRAC.EQ.1) DV=AVBAR/4.			000120
		IF (IMIRAC.EQ.2) DV=ALBAR/4.			000130
85		IF (IMIRAC.EQ.3) DV=ADBAR/4.			000140
120		CONTINUE			000150
		PRINT*, "FIRST DV = ",DV			000160
		IF (NLAYER.NE.1) GO TO 130			000170
C		DV IS ASSUMED TO BE .LT. 1			000180
90		ISCAL=ALOSLS(DV) - 2.			000190
		SCAL=10.**ISCAL			000200
		IDV=(DV/SCAL) + 0.5			000210
		DV=SCAL*FLOAT(IDV)			000220
95		GO TO 170			000230
130		TYPE=OLDV/DV			000240
		IF (TYPE.GE.1.) GO TO 135			000250
		TYPE=1.0/TYPE			000260
		ISMAIL=1			000270
135		PRINT*, "COMPUTED DV BEFORE MODIFICATION = ",DV			000280
C					000290
100		IF (TYPE .GT. 2.0) GO TO 150			000300
		IF (TYPE .GE. 1.001) GO TO 130			000310
		DV=OLDV			000320
		ITYPE=0			000330
105		GO TO 170			000340
130		ITYPE=1./(TYPE-1.0)+0.5			000350
		IF (ISMAIL .EQ. 0) DV=OLDV*FLOAT(ITYPE)/FLOAT(ITYPE+1)			000360
		IF (ISMAIL .EQ. 1) DV=OLDV*FLOAT(ITYPE+1)/FLOAT(ITYPE)			000370
		GO TO 170			000380
110		CONTINUE			000390
		PRINT *00			000400
		STOP			000410
170		PRINT *,DV,ITYPE			000420
C					000430
115		IF (IMIRAC.EQ.1) CALL MIRACV			000440
		IF (IMIRAC.EQ.2) CALL MIRACL			000450
		IF (IMIRAC.EQ.3) CALL MIRACD			000460
C					000470
		NPTS=1			000480
120		IF (IMIT.NE.0) GO TO 190			000490
		IF (NLAYER.GT.1) GO TO 120			000500
		GO TO 210			000510
180		CALL ADMMRG (ITYPE,ISMAIL,ILODPL,LFILE,MFILE)			000520
		GO TO 210			000530
125		CONTINUE			000540
C					000550
		IMIT=1 TO REACH THIS STATEMENT			000560
		IF (ISMAIL.NE.0) STOP " ISMAIL .NE. 0 "			000570
		IF (NLAYER.GT.1) GO TO 200			000580
		CALL EMINIT(ILOOK,TBOUND,MFILE)			000590
130		GO TO 210			000600
C					000610
200		IF (ILOOK.EQ.0) CALL ENUP (NPTS,ITYPE,LFILE,MFILE)			000620
		IF (ILOOK.EQ.1) CALL ENDOWN (NPTS,ITYPE,LFILE,MFILE)			000630
C					000640
135		CONTINUE			000650
		MSTOR=MFILE			000660
		MFILE=LFILE			000670
		LFILE=MSTOR			000680
230		REWIND 11			000690
140		REWIND 12			000700
		ILODPL=MPANEL			000710
		MPANEL=0			000720
		KFILE=10			000730
280		CONTINUE			000740
330		REWIND 11			000750
C					000760
C					000770
330		IF (IFLCT.NE.0) CALL TPLOT(TPLOT,MFILE)			000780
330		STOP			000790

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PTN 4.6428

23/14/70

Line	Code	Text	Address
150	C		001900
	C		001000
	C		001010
	900	FORMAT(1M1)	001020
	905	FORMAT(1M0)	001030
155	910	FORMAT(10A10)	001040
	920	FORMAT(10T5)	001050
	930	FORMAT(1M0,10A10)	001060
	940	FORMAT(10F10.7)	001070
	950	FORMAT(10 SECANT = *,F19.8)	001080
160	960	FORMAT(9X,A6,3H = ,I1)	001090
	970	FORMAT(10 LOWEST LINE = *F10.3,* HIGHEST LINE = * F10.3)	001700
	980	FORMAT(10 THE RATIO OF OLD DV TO NEW DV EXCEEDS 2.0 *)	001710
	C		001720
	END		001730

FTN 4.64428

03/14/78

```

1      SUBROUTINE W1ACV
C
C
C.....
5      *
*
*      CALCULATES MONOCHROMATIC ABSORPTION COEFFICIENT FOR SINGLE LAYER *
*
*
10     *
*      USES APPROXIMATE VOIGT ALGORITHM
*
C.....
C
C
15     COMMON GNU(250),S(250),ALFA0(250),EPP(250),POL(250),
C          EPOPTM(250),RECALF(250),ZETA1(250),IZETA(250)
COMMON FF(3000),SF(400),VSF(225)
COMMON/MAIN/ KFILE,KPANEL,P0,TEMPO
COMMON/NEW/  MHOL,XID(7),RECAT,PAVE,TAVE,MHOLID(7),MK(7),
C          OV,V1,V2,NLAYER
COMMON /XSUB/LININ,ILC,INI,VBOT,VTOP,VFT,IEOF,IPANEL,ISTOP,IDATA
COMMON /MXK/  MHF,DXF,MF,MNS,DXS,MS,MHVS,DXVS,MVS,MFMX,MNSMX,MVSM
1AX
COMMON /SUB1/  MAXF,MXS,MAXVS,NLINF,NLINS,NLIPVS,NLO,NMI,OVS,DVVS
2X
COMMON /KPANEL/ V1P,VFP,OVP,NLIN,NSHIFT,NPTS
COMMON/XTIME/TIME,TIMROF,TIMCNV,TIMPHL
COMMON/VOICOM/AVRAT(201),CLD(201)
DIMENSION ALFCOR(7),ALF01(7),U(7),SCOR(7)
DIMENSION XF(251),XS(251),XVS(251),XD(251)
30
C
DATA MHF / 4/, DXF / 0.92/, MF /201/, MFMX /251/
DATA MNS /10/, DXS / 0.00/, MS /201/, MNSMX /251/
DATA MHVS/04/, DXVS/ 0.3E/, MVS/201/, MVSMX/251/
35
C
DATA IENTER/0/, LININ/250/, NSHIFT/32/, NLINF/2401/, NPTS/ 0/
C
DATA SUBID /10H VOIGT /
C
IF (IENTER.NE.0) GO TO 10
IENTER=1
NLINS=(NLINF/4)+1
NLIPVS=(NLINS/4)+1
C
NOTE (DXVS/DXF) IS 16 AND (DXVS/DXS) IS 4
MBOUND=FLOAT(MHVS)*(DXVS/5XF)
MAXF=K*INF+MBOUND
MAXS=(MAXF/4)+1
MAXVS=(MAXS/4)+1
CALL VOICOM
CALL SHAPEL(XF,XS,XVS)
CALL SHAPED(XD)
CALL MLEGL(1,MHOLID,MHOL,TEMPO,TAVE,P0,PAVE,SCOR,ALFCOR,ALF01)
10     PRINT 000

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SUBROUTINE KIRACV

7/4/74 CPT=1

FTN 4.6-428

03/14/78

```

      PRINT 979, SUBID                                002260
      TIMRDP=TIMCHV+TIMPHL=0.                          002270
      PRINT 984, (XID(I),I=1,7)                       002280
      RENING KFILE                                     002290
      IEOP=0                                            002300
      PRINT 910, KFILE                                  002310
      PRINT 915, SECANT                                002320
      PRINT 925, PAVE,TAVE                             002330
      PRINT 930, (HMOLID(M),MK(M),M=1,NMOL)           002340
      PRINT 940, DV,V1,V2                              002350
      DVP=DV                                            002360
      DVS=(DXS/DNF)*DV                                  002370
      DVVS=(DXVS/DNF)*DV                               002380
      SOUND=FLOAT(NBOUND)*DV/2.                       002390
      SOUNVS=SOUND/2.                                  002400
      PRINT 942, SOUNVS                                002410
      ALFMA=SOUND/FLOAT(NMVS)                          002420
      NLC=NBOUND+1.                                    002430
      NMH=NLMF+NSHIFT-1                                002440
      DO 50 I=1,MAXF                                    002450
50      FF(I)=0.                                        002460
      DO 60 I=1,MAXS                                    002470
60      SF(I)=0.                                        002480
      DO 70 I=1,MAXVS                                   002490
70      VSF(I)=0.                                       002500
      C                                                  002510
      S WRITE (KFILE) (XID(I),I=1,7),SECANT,PAVE,TAVE,(HMOLID(M),M=1,7), 002520
      S (MK(I),I=1,NMOL),DV,V1,V2                    002530
      BUFFER OUT(KFILE,1) (XID(1),NLAVER)             002540
      IF (UNIT(KFILE).EQ.0) STOP "99"                 002550
      C                                                  002560
      VFT=V1-2.*SOUND                                  002570
85      VBOT=V1-SOUND                                  002580
      C                                                  002590
      VTOP=V2+SOUND                                     002600
      C                                                  002610
      XKT0=0.6951*TEMP0                                 002620
      XKT =0.6951*TAVE                                  002630
      XKTFA0=(1./XKT) - (1./XKT0)                     002640
      CALL MOLEC(2,NMOLID,NMOL,TEMP0,TAVE,P0,PAVE,SCOR,ALFCOR,ALFD1) 002650
      DO 80 M=1,NMOL                                   002660
80      U(M)=MK(M)*SCOR(M)*SECANT                     002670
      ICAT=0                                            002680
      SUMALF=0.                                         002690
      SUM7ET=0.                                         002700
      NCHNG=0                                           002710
      C                                                  002720
      90 CONTINUE                                       002730
      C                                                  002740
100      CONTINUE                                       002750
      C                                                  002760
      CALL SECOND (TIME0)                               002770
      IF (IEOP.NE.0) GO TO 130                         002780
      CALL RDPFILE(GNU,S,ALFA0,EPP,NOL)                002790
      CALL SECOND (TIME)                               002800
      TIMRDP=TIMRDP+TIME-TIME0                         002810
      C                                                  002820
      IF (IEOP.NE.0) GO TO 140                         002830
110      C                                                  002840
      C MODIFY LINE DATA FOR TEMPERATURE,PRESSURE, AND COLUMN DENSITY 002850
      C                                                  002860
      DO 130 I=ILO,IMI                                  002870
      NMHOL(I)                                         002880
115      EFCPTH(I)=S(I)*U(M)                          002890
      IF (EFCPTH(I).LE.0.) GO TO 130                  002900
      ICNT=ICNT+1                                       002910
      ALFL=ALFA0(I)*ALFCOR(M)                         002920
      ALFAD=GNU(I)*ALFD1(M)                           002930
      ZETA=ALFL/(ALFL+ALFAD)                          002940
      IZ=ZETA*ZETA+1.5                                 002950
      ALFV=AVRAT(IZ)*ALFL                             002960
      IF (IZ.L1.101) ALFV=AVRAT(IZ)*ALFAD             002970
      IF (ALFV.GE.DV) GO TO 110                       002980
125      PRINT 945, GNU(I),S(I),ALFA0(I),ALFV,DV,M    002990
      ALFV=CV

```


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	SUBROUTINE NIMROV	74/74	OPT=1	FTN 6.6-428	03/14/78
					003800
					003810
110					003820
					003830
130					003840
					003850
					003860
					003870
					003880
130					003890
					003900
					003910
					003920
					003930
					003940
140					003950
					003960
					003970
					003980
					003990
145					004000
					004010
					004020
					004030
150					004040
					004050
					004060
					004070
					004080
					004090
					004100
					004110
					004120
					004130
					004140
					004150
					004160
					004170
					004180
					004190
					004200
					004210
					004220
					004230
					004240
					004250
					004260
					004270
					004280
					004290
					004300
					004310
					004320
					004330
					004340
					004350
					004360
					004370
					004380
					004390
					004400
					004410
					004420
					004430
					004440
					004450
					004460
					004470
					004480
					004490
					004500
					004510
					004520
					004530
					004540
					004550
					004560
					004570
					004580
					004590
					004600
					004610
					004620
					004630
					004640
					004650
					004660
					004670
					004680
					004690
					004700
					004710
					004720
					004730
					004740
					004750
					004760
					004770
					004780
					004790
					004800
					004810
					004820
					004830
					004840
					004850
					004860
					004870
					004880
					004890
					004900
					004910
					004920
					004930
					004940
					004950
					004960
					004970
					004980
					004990
					005000

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SUBROUTINE ROPFILE 74/74 OPT=1

FTN 4.6-428

33/14/78

```

1      SUBROUTINE ROPFILE (GNU,S,ALFAS,EPP,MOL)
COMMON /XSUB/LIMIN,ILO,INI,VBOT,VTOP,VFT,IEOF,IPANEL,ISTOP,IDATA
COMMON /BUFF/ VMIN,VMAX,NREC
DIMENSION GNU(1), S(1), ALFAS(1), EPP(1), MOL(1)
5      DATA LIMPIL /3/, I1 /1/, I2 /2/
      IDATA=0
      S 10  READ (LIMPIL) VMIN,VMAX,NREC
      S    IF (EPP(LIMPIL) .NE. 3) GO TO 80
      10  BUFFER IN (LIMPIL,1) (VMIN,NREC)
      10  IF (UNIT(LIMPIL) .EQ. 8) GO TO 80
      IF (NREC.GT.LIMIN) STOP = LIMIN =
      IF (VMAX.GE.VBOT) GO TO 30
      S    READ (LIMPIL) VMIN
      BUFFER IN (LIMPIL,1) ( GNU(I1),GNU(I2) )
      15  IF (UNIT(LIMPIL) .EQ. 8) STOP
      GO TO 10
      S 30  READ (LIMPIL) (GNU(I1),S(I1),ALFAS(I1),EPP(I1),MOL(I1),I=1,NREC)
      30  BUFFER IN (LIMPIL,1) ( GNU(I1),MOL(LIMIN) )
      IF (UNIT(LIMPIL) .EQ. 8) STOP
      20  ILC=1
      INI=NREC
      IF (VMIN.GE.VBOT) GO TO 20
      DO 40 I=1,NREC
      ILO=I
      25  IF (GNU(I).GE.VBOT) GO TO 50
      40  CONTINUE
      50  IF (VMAX.LE.VTOP) RETURN
      70  I=I+1,NREC
      INI=I
      30  IF (GNU(I).GT.VTOP) GO TO 70
      60  CONTINUE
      70  IF (INI.LT.NREC) IDATA=1
      RETURN
      35  PRINT 920
      IEOF=1
      RETURN
      C
      C
      920  FORMAT ('* END OF FILE ON DISK')
      END

```

SUBROUTINE CONVFNV 74/74 OPT=1

FTN 4.6-428

33/14/78

```

1      SUBROUTINE CONVFNV(GNU,EFOPTH,RECALF,MOL,FF,SP,VSF,XF,XS,XVS,XD,
C      ZETA1,ZETA2)
COMMON /NFN/ NMOL,XID(7),SECANT,PAVE,TAVE,NMOLID(7),WK(7),
C      DV,V1,V2,NLAYER
5      COMMON /XSUB/LIMIN,ILO,INI,VBOT,VTOP,VFT,IEOF,IPANEL,ISTOP,IDATA
COMMON /WXX/ NMF,DMF,MF,NMS,OMS,MS,NMVS,DXVS,MVS,NFMX,MNSHAX,MVSM
1AX
COMMON /SUB1/ 4AXF,MAXS,MAXVS,NLINF,NLINS,NLIMVS,NLO,M'T,DVS,DVVS
COMMON /VTIME/TIME,TIMROF,TIMCNV,TIMPMI
10  COMMON /VOICOM/AVRAT(201),CLO(201)
DIMENSION GNU(1), EFOPTH(1), RECALF(1), MOL(1)
DIMENSION FF(1), SP(1), VSF(1)
DIMENSION XF(1), XS(1), XVS(1)
DIMENSION XD(1)
15  DIMENSION IZETA(1),ZETA1(1)
CALL SECOND (TIME0)
RATVX=DVS/DXVS
FVS=FLOAT(NMVS)/DXVS
CONF=DVS/DV-1.
CONVS=DVS/FVS-1.
20  IF (ILO.GT.INI) GO TO 50
DO 40 I=ILO,INI
DEPTM=EFOPTH(I)
IF (DEPTM.LE.0.) GO TO 40
25  IZ=IZETA(I)
SYRL=DEPTM-CLD(I)
STOP=DEPTM*(1.-CLD(I))

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SUBROUTINE CONVPVW		74/74	OPT=1	FTN 4.6+428	03/14/78
--------------------	--	-------	-------	-------------	----------

30		ZSLOPE=RECIP(1+NYTV)	004258
		ZINT=(RMJ(1)-VFT)/DVVS	004260
		BPVS=PVS/ZSLOPE	004270
		JMAX=(ZINT*BPVS)+2.	004280
		IF (JMAX.LE.NXVS) GO TO 20	004290
		ILAST=1	004300
		GO TO 50	004310
35	20	JMIN=(ZINT*BPVS)+2.	004320
		JMINF=(ZINT*CONF)	004330
		JMINS=(ZINT*CONS)	004340
		ZVS=(FLOAT(JMIN-2)-ZINT)*ZSLOPE	004350
		ZS=ZVS*(FLOAT(JMINS)-ZINT*CONS)*ZSLOPE	004360
40		ZF=ZVS*(FLOAT(JMINF)-ZINT*CONF)*ZSLOPE	004370
		DC 30 JJ=JMIN,JMAX	004380
		JS=JMINS+JJ	004390
		JF=JMINF+JJ	004400
		ZVS=ZVS+ZSLOPE	004410
45		ZS=ZS+ZSLOPE	004420
		ZF=ZF+ZSLOPE	004430
		IZVS=ABS(ZVS)+1.5	004440
		IJS=ABS(JS)+1.5	004450
		IZF=ABS(ZF)+1.5	004460
50		VSP(JJ)=VSP(JJ)+STRL*VVS(IZVS)	004470
		SF(JS)=SF(JS)+STRL*VS(IZS)	004480
		FF(JF)=FF(JF)+STRL*VF(IZF)+STRO*NO(IZF)	004490
	30	CONTINUE	004500
	40	CONTINUE	004510
55		ILAST=ZINT	004520
	C	IDATA=0 FOR MORE DATA REQUIRED ** IDATA=1 IF NO MORE DATA REQUIRED	004530
		IPANEL=IDATA	004540
		GO TO 60	004550
	40	CONTINUE	004560
60		IPANEL=1	004570
	60	ILO=ILAST+1	004580
		CALL SECOND (TIME)	004590
		TIMCNV=TIMCNV+TIME-TIME0	004600
		RETURN	004610
65	C		004620
		END	004630

SUBROUTINE PANEL		74/74	OPT=1	FTN 4.6+428	03/14/78
------------------	--	-------	-------	-------------	----------

1		SUBROUTINE PANEL (FF,SF,VSP,KFILE)	004640
		COMMON/NEW/ NHOL,XID(7),SECANT,PAVE,TAVE,NHOL7(7),WK(7),	004650
		OV,V1,V2,NLAYER	004660
	C	COMMON /XSUB/LIMN,ILC,INI,VBOY,VTOP,VFT,IEOP,IPANEL,ISTOP,IDATA	004670
5		COMMON /SUB1/ MAXF,MAXS,MAXVS,NLINF,KLINS,NLIPVS,NLO,NHI,DVS,DVVS	004680
		COMMON /XPNEL/ V1P,V2P,DVP,NLIN,NSHIFT,NPTS	004690
		COMMON /XTIME/TIME,TIMROF,TIMCNV,TIMPHL	004700
		DIMENSION FF(1), SF(1), VSP(1)	004710
		DIMENSION SFSTOR(8)	004720
10		CALL SECOND (TIME0)	004730
		X00=-7./120.	004740
		X01=105./120.	004750
		X02=35./120.	004760
		X03=-5./120.	004770
15		X10=-1./16.	004780
		X1=9./16.	004790
		TOP=0	004800
		NNHI=(V2-VFT)/DV+1.5	004810
		IF (NNHI.GE.NNHI) ISTOP=1	004820
20		IF (ISTOP.EQ.1) NHI=NNHI	004830
		JNXP=NLO+NPTS	004840
		JJPR=NHI-NPTS	004850
		LIMLO=(NLO-1)/4-3	004860
		LIMHI=(NHI/4)+1	004870
25		SLOW FUNCTION VALUES NEEDED FOR SUBSEQUENT PANELVS ARE SAVED	004880
		DO 10 J=1,8	004890
	10	SFSTOR(J)=SF(LIMHI+J-5)	004900
		DC 20 J=LIMLO,LIMHI,4	004910
		JVS=(J-1)/4+1	004920

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SUBROUTINE PANEL      74/74    OPT=1      FTM 4.6+628      03/14/76

30      SF(J)=SF(J)+VSF(JVS)
      SF(J+1)=SF(J+1)+X00*VSF(JVS-1)+X01*VSF(JVS)+X02*VSF(JVS+1)+X03*VSF
1(JVS+2)
      SF(J+2)=SF(J+2)+X10*(VSF(JVS-1)+VSF(JVS+2))+X11*(VSF(JVS)+VSF(JVS+
11))
35      SF(J+3)=SF(J+3)+X03*VSF(JVS-1)+X02*VSF(JVS)+X01*VSF(JVS+1)+X00*VSF
1(JVS+2)
20      CONTINUE
      DO 30 J=NLO,NHI,4
      JS=(J-1)/4+1
40      FF(J)=FF(J)+SF(JS)
      FF(J+1)=FF(J+1)+X00*SF(JS-1)+X01*SF(JS)+X02*SF(JS+1)+X03*SF(JS+2)
      FF(J+2)=FF(J+2)+X10*(SF(JS-1)+SF(JS+2))+X11*(SF(JS)+SF(JS+1))
      FF(J+3)=FF(J+3)+X03*SF(JS-1)+X02*SF(JS)+X01*SF(JS+1)+X00*SF(JS+2)
30      CONTINUE
45      IF (NPTS.EQ.0) GO TO 60
      DO 40 J=NLO,JHPR
      VP=VFT+FLOAT(J-1)*DV
40      PRINT 900, J,FF(J),VP
      DO 50 J=JHPR,NHI
      VP=VFT+FLOAT(J-1)*DV
50      PRINT 900, J,FF(J),VP
60      CONTINUE
      DO 70 J=1,8
70      SF(LI+J-5)=SFSTOR(J)
55      NLIM=NHI-NLO+1
      VIP=VFT+FLOAT(NLO-1)*DV
      VZP=VFT+FLOAT(NHI-1)*DV
      C      VIP IS FIRST FREQ OF PANELV
      C      VZP IS LAST FREQ OF PANELV
60      S      WRITE (KFILE) VIP,VZP,DVP,NLIM
      S      WRITE (KFILE) (FF(J),J=NLO,NHI)
      BUFFER OUT (KFILE,1) (VIP,NLIM)
      IF (UNIT(KFILE).EQ.0) STOP
      BUFFER OUT (KFILE,1) (FF(NLO),FF(NHI))
65      IF (UNIT(KFILE).EQ.0) STOP
      VFT=VFT+FLOAT(NLIM-1)*DV
      IF (ISTOP.EQ.1) GO TO 140
      JF=1
      DO 80 J=NLIMF,MAXF
70      FF(JF)=FF(J)
      80      JF=JF+1
      DO 90 J=JF,MAXF
      90      FF(J)=0.
      JS=1
75      DO 100 J=NLIMS,MAXS
      SF(JS)=SF(J)
      100      JS=JS+1
      DO 110 J=JS,MAXS
      110      SF(J)=0.
      JVS=1
80      DO 120 J=NLIMVS,MAXVS
      VSF(JVS)=VSF(J)
      120      JVS=JVS+1
      DO 130 J=JVS,MAXVS
      130      VSF(J)=0.
85      NLO=NSMT+1
      140      CALL SECOND (TIME)
      TIMPNL=TIMPNL+TIME-TIME0
      RETURN
90      C
      C
      C
      900      FORMAT (I10,24X,E12.5,F12.5)
      END

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SUBROUTINE MOLEC      74/74    OPT=1      FTH 4.6+428      03/14/78

1      SUBROUTINE MOLEC(IND,MHOLID,MHOLEC,TEMP0,TEMP,PV,P,SCOR,ALFCOR,      005500
C ALPDI1)              005510
C ALPDI1)              005520
DIMENSION MHOLID(1),SCOR(1),ALFCOR(1),ALPDI(1)      005530
DIMENSION M(7,4),MD(7,4),SMASS(7)      005540
COMMON /MHOLEC/ MH(7),MV(7),M1(7),M2(7),M3(7),M4(7),      005550
1 M5(7),M6(7),M7(7),M8(7),QV0(7),ROTFC(7)      005560
C      DATA AV06/6.0249E 23/, BOLTZ/1.3803E-16/, CLIGHT/2.997925E 10/      005570
C      DATA MH,SMASS,MV,M1,M2,M3,M4,M5,M6,M7,M8,QV0,ROTFC /      005580
2      1 MH M20 ,6M C02 ,6M O3 ,6M M20 ,6M CO ,6M CH4 ,6M O2 ,      005590
3      10. , 44. , 48. , 44. , 28. , 16. , 32. ,      005600
4      3 , 3 , 3 , 3 , 1 , 4 , 1 ,      005610
5      3651.7 , 1364.0 , 1103.2 , 1204.0 , 2143.3 , 2914. , 1485.3 ,      005620
6      1 , 1 , 1 , 1 , 1 , 1 , 1 ,      005630
7      1905.0 , 667.3 , 780.0 , 500.0 , 0. , 1533.3 , 0. ,      005640
8      1 , 2 , 1 , 2 , 0 , 2 , 0 ,      005650
9      3755.0 , 2349.3 , 1042.1 , 2223.0 , 0. , 3818.0 , 0. ,      005660
10     1 , 1 , 1 , 1 , 0 , 3 , 0 ,      005670
11     A 0. , J. , 0. , 0. , 0. , 1297.0 , 0. ,      005680
12     0 , 0 , 0 , 0 , 0 , 3 , 0 ,      005690
13     C 1.0004 , 1.0048 , 1.0456 , 1.1267 , 1.0000 , 1.0066 , 1.0007 ,      005700
14     D 1.5 , 1.0 , 1.5 , 1.0 , 1.0 , 1.5 , 1.0 /      005710
C      MOLEC MAKES THE MOLECULAR IDENTIFICATIONS      005720
C      SCOR IS THE FACTOR BY WHICH THE LINE INTENSITY IS CHANGED DUE TO      005730
C      TEMPERATURE DEPENDENCE OF THE VIB AND ROT PARTITION SUMS      005740
C      ALFCOR IS THE FACTOR BY WHICH THE COLLISION WIDTH MUST BE CHANGED      005750
C      DUE TO THE DEPENDENCE ON PRESSURE AND TEMPERATURE      005760
C      THE TEMPERATURE DEPENDENCE IS TAKEN AS (T0/T)**0.5      005770
C      ALPDI CONTAINS THE DOPPLER WIDTHS AT 1 CM-1      005780
C      IF (IND.EQ.2) GO TO 20      005790
C      MDIM=7      005800
C      NYDIM=4      005810
C      CJ 10 M=1,MHOLEC      005820
C      M(M,1)=M1(M)      005830
C      M(M,2)=M2(M)      005840
C      M(M,3)=M3(M)      005850
C      M(M,4)=M4(M)      005860
C      MD(M,1)=M1(M)      005870
C      MD(M,2)=M2(M)      005880
C      MD(M,3)=M3(M)      005890
C      MD(M,4)=M4(M)      005900
C      FLN2=ALOG(2.)      005910
C      MHOLID(M)=MH(M)      005920
C      PAD=FLN2*2.*AV06*BOLTZ/(CLIGHT*CLIGHT)      005930
C      RETURN      005940
C      CONTINUE      005950
C      PRATIO=P/P0      005960
C      TRATIO=TEMP0/TEMP      005970
C      XKT=8.6951*TEMP      005980
C      DO 30 M=1,MHOLEC      005990
C      SCOR(M)=QV0*ROTFC(M,XKT,TRATIO,QV0,ROTFC,M,M0,MDIM,MVDIM)      006000
C      ALFCOR(M)=PRATIO*(TRATIO**0.5)      006010
C      ALPDI(M)=SQRT(PAD*TEMP/SMASS(M))      006020
C      CONTINUE      006030
C      RETURN      006040
C      END      006050

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FUNCTION OVRFAC 74/74 OPT=1

FTN 4.6+428

33/14/74

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1      FUNCTION OVRFAC(M,XKT,TRATIO,QVB,ROTFAC,N,ND,MNDIM,NVDIM)
      DIMENSION QVB(1),ROTFAC(1)
      DIMENSION MNDIM,MNDIM,MNDIM,MNDIM,MNDIM,MNDIM,MNDIM,MNDIM
      QVB=1.
      DO 10 I=1,MNDIM
      IF (MNDIM(I).EQ.0) GO TO 20
      SV=1.-EXP(-MNDIM(I)/XKT)
      IF (MNDIM(I).GT.1) SV=SV**MNDIM(I)
      QVB=QVB*SV
10     QVRFAC=(QVB(M)/QVB)*(TRATIO**ROTFAC(M))
20     RETURN
      C
      END

```

SUBROUTINE SHAPEL 74/74 OPT=1

FTN 4.6+428

03/14/78

```

1      SUBROUTINE SHAPEL(XF,XS,XVS)
      COMMON /XXX/ NMF,DXF,NF,NMS,DXS,NS,NMVS,DXVS,AVS,NFMAX,NSMAX,NVSM
      1AX
      DIMENSION XF(1),XS(1),XVS(1)
      XLORNZ(X2)=1./(1.+X2)
      SPN(X2)=A1+A1*X2+C1*X2*X2
      VSPN(X2)=A2+B2*X2+C2*X2*X2
      A1(20)=(1.+3.*20**2+3.*20**4)/(1.+20**2)**3
      A2(20)=(1.+3.*20**2)/(1.+20**2)**3
      C1(20)=1./(1.+20**2)**3
10     CATCH AT 71 HALFWIDTHS
      71=4.
      A1=A1(71)
      B1=B1(71)
      C1=C1(71)
15     CATCH AT 72 HALFWIDTHS
      72=16.
      A2=A2(72)
      B2=B2(72)
      C2=C2(72)
20     RCFI=1./(2.*ASIN(1.))
      TOTAL=0.
      DO 10 I=1,NFMAX
      XF(I)=0.
25     XF(1)=RCFI*(XLORNZ(0.)-SPN(0.))
      SUM=XF(1)
      NG 20 JJ=2,NF
      X=FLOAT(JJ-1)*DXF
      X2=X*X
30     XF(JJ)=RCFI*(XLORNZ(X2)-SPN(X2))
      SUM=SUM+XF(JJ)*2.
      CONTINUE
      XF(NF)=0.
      SUM=SUM+DXF
      TOTAL=TOTAL+SUM
35     DO 30 I=1,NSMAX
      XS(I)=0.
      XS(1)=RCFI*(SPN(0.)-VSPN(0.))
      SUM=XS(1)
40     NS1=FLOAT(NMF)*DXS+1.001
      DO 40 JJ=2,NS1
      X=FLOAT(JJ-1)*DXS
      X2=X*X
45     XS(JJ)=RCFI*(VSPN(X2)-VSPN(X2))
      SUM=SUM+XS(JJ)*2.
      CONTINUE
      NS1=NS1+1
      DO 50 JJ=NS1,NS
      X=FLOAT(JJ-1)*DXS
      X2=X*X
50     XS(JJ)=RCFI*(XLORNZ(X2)-VSPN(X2))
      SUM=SUM+XS(JJ)*2.
      CONTINUE
      XS(NS)=0.

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SUBROUTINE SHAPEL 74/74 OPT=1 PFM 4.6+428 03/14/78

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55      SUM=SUM*DXS
      TOTAL=TOTAL+SUM
      DO 60 J=1,NVSMAT
60      XVS(I)=0.
      XVS(I)=RECPI*VSFN(I.)
      SUM=XVS(I)
      NVS1=FLOAT(NVSI)/CXVS+1.001
      DO 70 JJ=2,NVSI
      X=FLOAT(JJ-1)*DXVS
      X2=X*X
      XVS(JJ)=RECPI*VSFN(X2)
      SUM=SUM+XVS(JJ)*2.
70      CONTINUE
      NS1P=NVS1+1
      DO 80 JJ=NS1P,NVS
      X=FLOAT(JJ-1)*DXVS
      X2=X*X
      XVS(JJ)=RECPI*(X*LN2*(X2))
      SUM=SUM+XVS(JJ)*2.
80      CONTINUE
      SUM=SUM*DXVS
      TOTAL=TOTAL+SUM
      RETURN
      C
      C
80      C
      END

```

006910
006920
006930
006940
006950
006960
006970
006980
006990
007000
007010
007020
007030
007040
007050
007060
007070
007080
007090
007100
007110
007120
007130
007140
007150
007160
007170

SUBROUTINE SHAPED 74/74 OPT=1 PFM 4.6+428 03/14/78

```

1      SUBROUTINE SHAPED(XD)
      COMMON /HXY/ NMF,DXF,NF,NMS,DXS,NS,NMVS,DXVS,NVS,NFMAX,NSMAX,NVSM
      1AX
      DIMENSION XD(1)
      XGAUSS(X2)=EXP(-1.*FLN2*X2)
      FLN2=ALOG(2.)
      RECPI=1./(2.*ASTN(1.))
      XDNORM=SQRT(FLN2*RECPI)
      TOTAL=0.
      DO 10 I=1,NFMAX
10      XD(I)=0.
      XD(1)=XDNORM*XGAUSS(I.)
      SUM=XD(1)
      DO 20 JJ=2,NF
      X=FLOAT(JJ-1)*DXF
      X2=X*X
      XD(JJ)=XDNORM*XGAUSS(X2)
      SUM=SUM+XD(JJ)*2.
20      CONTINUE
      XC(NF)=0.
      SUM=SUM*DXF
      TOTAL=TOTAL+SUM
      RETURN
      END

```

007180
007190
007200
007210
007220
007230
007240
007250
007260
007270
007280
007290
007300
007310
007320
007330
007340
007350
007360
007370
007380
007390
007400
007410

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ROUTINE VOICOM

74/74 OPT=1

PTM 6.0-428

32/16/78

```

1      SURROUTINE VOICOM
      COMMON /VOICOM/ AVRAT(201),CLO(201)
      LORENTZ AND DOPPLER FUNCTIONS DECOMPOSED OVER THE INTERVALS
      0-4, 0-10, 0-64
      WEIGHTING FUNCTIONS WAS 1. / VOIGT
      DATA (AVRAT(I),I=1,40) /
C      .1000000E+01, .1002000E+01, .1005000E+01, .1008100E+01,
C      .1010000E+01, .1013772E+01, .1016620E+01, .1019922E+01,
C      .1022451E+01, .1025410E+01, .1028022E+01, .1031460E+01,
10     C      .1034547E+01, .1037609E+01, .1040831E+01, .1044020E+01,
C      .1047201E+01, .1050571E+01, .1053906E+01, .1057280E+01,
C      .1060790E+01, .1064176E+01, .1067693E+01, .1071250E+01,
C      .1074870E+01, .1078541E+01, .1082250E+01, .1086027E+01,
C      .1089850E+01, .1093728E+01, .1097661E+01, .1101652E+01,
15     C      .1105700E+01, .1109800E+01, .1113970E+01, .1118200E+01,
C      .1122490E+01, .1126857E+01, .1131201E+01, .1135772E+01,
C      /
      DATA (AVRAT(I),I=41,80) /
C      .1140332E+01, .1144862E+01, .1149665E+01, .1154641E+01,
C      .1159792E+01, .1164221E+01, .1168920E+01, .1174310E+01,
C      .1179440E+01, .1184730E+01, .1190000E+01, .1195500E+01,
C      .1201220E+01, .1206640E+01, .1212340E+01, .1218151E+01,
C      .1224056E+01, .1230050E+01, .1236160E+01, .1242380E+01,
C      .1248712E+01, .1255151E+01, .1261700E+01, .1268370E+01,
25     C      .1275172E+01, .1282000E+01, .1288910E+01, .1295913E+01,
C      .1303025E+01, .1310167E+01, .1318060E+01, .1326400E+01,
C      .1334290E+01, .1342330E+01, .1350520E+01, .1358860E+01,
C      .1367410E+01, .1376110E+01, .1384991E+01, .1394060E+01,
C      /
30     DATA (AVRAT(I),I=81,120) /
C      .1403291E+01, .1412727E+01, .1422360E+01, .1432197E+01,
C      .1442246E+01, .1452500E+01, .1462991E+01, .1473730E+01,
C      .1484654E+01, .1495864E+01, .1507292E+01, .1518999E+01,
C      .1530969E+01, .1543210E+01, .1555740E+01, .1568563E+01,
35     C      .1581660E+01, .1595127E+01, .1608890E+01, .1622960E+01,
C      .1637427E+01, .1651950E+01, .1666806E+01, .1681930E+01,
C      .1697205E+01, .1712807E+01, .1728693E+01, .1744930E+01,
C      .1761445E+01, .1778277E+01, .1795390E+01, .1812830E+01,
C      .1830604E+01, .1848745E+01, .1867200E+01, .1885997E+01,
40     C      .1905165E+01, .1924745E+01, .1944685E+01, .1964930E+01,
C      .1985500E+01, .2006425E+01, .2027745E+01, .2049400E+01,
C      /
      DATA (AVRAT(I),I=121,160) /
C      .2071421E+01, .2093665E+01, .2116277E+01, .2139347E+01,
C      .2162882E+01, .2186897E+01, .2211400E+01, .2236900E+01,
C      .2262400E+01, .2288900E+01, .2315400E+01, .2342900E+01,
C      .2370400E+01, .2397900E+01, .2425400E+01, .2452900E+01,
45     C      .2480400E+01, .2507900E+01, .2535400E+01, .2562900E+01,
C      .2590400E+01, .2617900E+01, .2645400E+01, .2672900E+01,
C      .2700400E+01, .2727900E+01, .2755400E+01, .2782900E+01,
C      .2810400E+01, .2837900E+01, .2865400E+01, .2892900E+01,
C      .2920400E+01, .2947900E+01, .2975400E+01, .3002900E+01,
50     C      .3030400E+01, .3057900E+01, .3085400E+01, .3112900E+01,
C      .3140400E+01, .3167900E+01, .3195400E+01, .3222900E+01,
C      .3250400E+01, .3277900E+01, .3305400E+01, .3332900E+01,
C      .3360400E+01, .3387900E+01, .3415400E+01, .3442900E+01,
C      .3470400E+01, .3497900E+01, .3525400E+01, .3552900E+01,
55     C      .3580400E+01, .3607900E+01, .3635400E+01, .3662900E+01,
C      .3690400E+01, .3717900E+01, .3745400E+01, .3772900E+01,
C      .3800400E+01, .3827900E+01, .3855400E+01, .3882900E+01,
C      .3910400E+01, .3937900E+01, .3965400E+01, .3992900E+01,
C      .4020400E+01, .4047900E+01, .4075400E+01, .4102900E+01,
60     C      .4130400E+01, .4157900E+01, .4185400E+01, .4212900E+01,
C      .4240400E+01, .4267900E+01, .4295400E+01, .4322900E+01,
C      .4350400E+01, .4377900E+01, .4405400E+01, .4432900E+01,
C      .4460400E+01, .4487900E+01, .4515400E+01, .4542900E+01,
C      .4570400E+01, .4597900E+01, .4625400E+01, .4652900E+01,
65     C      .4680400E+01, .4707900E+01, .4735400E+01, .4762900E+01,
C      .4790400E+01, .4817900E+01, .4845400E+01, .4872900E+01,
C      .4900400E+01, .4927900E+01, .4955400E+01, .4982900E+01,
C      .5010400E+01, .5037900E+01, .5065400E+01, .5092900E+01,
C      .5120400E+01, .5147900E+01, .5175400E+01, .5202900E+01,
70     C      .5230400E+01, .5257900E+01, .5285400E+01, .5312900E+01,
C      .5340400E+01, .5367900E+01, .5395400E+01, .5422900E+01,
C      .5450400E+01, .5477900E+01, .5505400E+01, .5532900E+01,
C      .5560400E+01, .5587900E+01, .5615400E+01, .5642900E+01,
C      .5670400E+01, .5697900E+01, .5725400E+01, .5752900E+01,
C      .5780400E+01, .5807900E+01, .5835400E+01, .5862900E+01,
C      .5890400E+01, .5917900E+01, .5945400E+01, .5972900E+01,
C      .6000400E+01, .6027900E+01, .6055400E+01, .6082900E+01,
C      .6110400E+01, .6137900E+01, .6165400E+01, .6192900E+01,
C      .6220400E+01, .6247900E+01, .6275400E+01, .6302900E+01,
C      .6330400E+01, .6357900E+01, .6385400E+01, .6412900E+01,
C      .6440400E+01, .6467900E+01, .6495400E+01, .6522900E+01,
C      .6550400E+01, .6577900E+01, .6605400E+01, .6632900E+01,
C      .6660400E+01, .6687900E+01, .6715400E+01, .6742900E+01,
C      .6770400E+01, .6797900E+01, .6825400E+01, .6852900E+01,
C      .6880400E+01, .6907900E+01, .6935400E+01, .6962900E+01,
C      .6990400E+01, .7017900E+01, .7045400E+01, .7072900E+01,
C      .7100400E+01, .7127900E+01, .7155400E+01, .7182900E+01,
C      .7210400E+01, .7237900E+01, .7265400E+01, .7292900E+01,
C      .7320400E+01, .7347900E+01, .7375400E+01, .7402900E+01,
C      .7430400E+01, .7457900E+01, .7485400E+01, .7512900E+01,
C      .7540400E+01, .7567900E+01, .7595400E+01, .7622900E+01,
C      .7650400E+01, .7677900E+01, .7705400E+01, .7732900E+01,
C      .7760400E+01, .7787900E+01, .7815400E+01, .7842900E+01,
C      .7870400E+01, .7897900E+01, .7925400E+01, .7952900E+01,
C      .7980400E+01, .8007900E+01, .8035400E+01, .8062900E+01,
C      .8090400E+01, .8117900E+01, .8145400E+01, .8172900E+01,
C      .8200400E+01, .8227900E+01, .8255400E+01, .8282900E+01,
C      .8310400E+01, .8337900E+01, .8365400E+01, .8392900E+01,
C      .8420400E+01, .8447900E+01, .8475400E+01, .8502900E+01,
C      .8530400E+01, .8557900E+01, .8585400E+01, .8612900E+01,
C      .8640400E+01, .8667900E+01, .8695400E+01, .8722900E+01,
C      .8750400E+01, .8777900E+01, .8805400E+01, .8832900E+01,
C      .8860400E+01, .8887900E+01, .8915400E+01, .8942900E+01,
C      .8970400E+01, .8997900E+01, .9025400E+01, .9052900E+01,
C      .9080400E+01, .9107900E+01, .9135400E+01, .9162900E+01,
C      .9190400E+01, .9217900E+01, .9245400E+01, .9272900E+01,
C      .9300400E+01, .9327900E+01, .9355400E+01, .9382900E+01,
C      .9410400E+01, .9437900E+01, .9465400E+01, .9492900E+01,
C      .9520400E+01, .9547900E+01, .9575400E+01, .9602900E+01,
C      .9630400E+01, .9657900E+01, .9685400E+01, .9712900E+01,
C      .9740400E+01, .9767900E+01, .9795400E+01, .9822900E+01,
C      .9850400E+01, .9877900E+01, .9905400E+01, .9932900E+01,
C      .9960400E+01, .9987900E+01, 1.0015400E+01, 1.0042900E+01,
C      1.0070400E+01, 1.0097900E+01, 1.0125400E+01, 1.0152900E+01,
C      1.0180400E+01, 1.0207900E+01, 1.0235400E+01, 1.0262900E+01,
C      1.0290400E+01, 1.0317900E+01, 1.0345400E+01, 1.0372900E+01,
C      1.0400400E+01, 1.0427900E+01, 1.0455400E+01, 1.0482900E+01,
C      1.0510400E+01, 1.0537900E+01, 1.0565400E+01, 1.0592900E+01,
C      1.0620400E+01, 1.0647900E+01, 1.0675400E+01, 1.0702900E+01,
C      1.0730400E+01, 1.0757900E+01, 1.0785400E+01, 1.0812900E+01,
C      1.0840400E+01, 1.0867900E+01, 1.0895400E+01, 1.0922900E+01,
C      1.0950400E+01, 1.0977900E+01, 1.1005400E+01, 1.1032900E+01,
C      1.1060400E+01, 1.1087900E+01, 1.1115400E+01, 1.1142900E+01,
C      1.1170400E+01, 1.1197900E+01, 1.1225400E+01, 1.1252900E+01,
C      1.1280400E+01, 1.1307900E+01, 1.1335400E+01, 1.1362900E+01,
C      1.1390400E+01, 1.1417900E+01, 1.1445400E+01, 1.1472900E+01,
C      1.1500400E+01, 1.1527900E+01, 1.1555400E+01, 1.1582900E+01,
C      1.1610400E+01, 1.1637900E+01, 1.1665400E+01, 1.1692900E+01,
C      1.1720400E+01, 1.1747900E+01, 1.1775400E+01, 1.1802900E+01,
C      1.1830400E+01, 1.1857900E+01, 1.1885400E+01, 1.1912900E+01,
C      1.1940400E+01, 1.1967900E+01, 1.1995400E+01, 1.2022900E+01,
C      1.2050400E+01, 1.2077900E+01, 1.2105400E+01, 1.2132900E+01,
C      1.2160400E+01, 1.2187900E+01, 1.2215400E+01, 1.2242900E+01,
C      1.2270400E+01, 1.2297900E+01, 1.2325400E+01, 1.2352900E+01,
C      1.2380400E+01, 1.2407900E+01, 1.2435400E+01, 1.2462900E+01,
C      1.2490400E+01, 1.2517900E+01, 1.2545400E+01, 1.2572900E+01,
C      1.2600400E+01, 1.2627900E+01, 1.2655400E+01, 1.2682900E+01,
C      1.2710400E+01, 1.2737900E+01, 1.2765400E+01, 1.2792900E+01,
C      1.2820400E+01, 1.2847900E+01, 1.2875400E+01, 1.2902900E+01,
C      1.2930400E+01, 1.2957900E+01, 1.2985400E+01, 1.3012900E+01,
C      1.3040400E+01, 1.3067900E+01, 1.3095400E+01, 1.3122900E+01,
C      1.3150400E+01, 1.3177900E+01, 1.3205400E+01, 1.3232900E+01,
C      1.3260400E+01, 1.3287900E+01, 1.3315400E+01, 1.3342900E+01,
C      1.3370400E+01, 1.3397900E+01, 1.3425400E+01, 1.3452900E+01,
C      1.3480400E+01, 1.3507900E+01, 1.3535400E+01, 1.3562900E+01,
C      1.3590400E+01, 1.3617900E+01, 1.3645400E+01, 1.3672900E+01,
C      1.3700400E+01, 1.3727900E+01, 1.3755400E+01, 1.3782900E+01,
C      1.3810400E+01, 1.3837900E+01, 1.3865400E+01, 1.3892900E+01,
C      1.3920400E+01, 1.3947900E+01, 1.3975400E+01, 1.4002900E+01,
C      1.4030400E+01, 1.4057900E+01, 1.4085400E+01, 1.4112900E+01,
C      1.4140400E+01, 1.4167900E+01, 1.4195400E+01, 1.4222900E+01,
C      1.4250400E+01, 1.4277900E+01, 1.4305400E+01, 1.4332900E+01,
C      1.4360400E+01, 1.4387900E+01, 1.4415400E+01, 1.4442900E+01,
C      1.4470400E+01, 1.4497900E+01, 1.4525400E+01, 1.4552900E+01,
C      1.4580400E+01, 1.4607900E+01, 1.4635400E+01, 1.4662900E+01,
C      1.4690400E+01, 1.4717900E+01, 1.4745400E+01, 1.4772900E+01,
C      1.4800400E+01, 1.4827900E+01, 1.4855400E+01, 1.4882900E+01,
C      1.4910400E+01, 1.4937900E+01, 1.4965400E+01, 1.4992900E+01,
C      1.5020400E+01, 1.5047900E+01, 1.5075400E+01, 1.5102900E+01,
C      1.5130400E+01, 1.5157900E+01, 1.5185400E+01, 1.5212900E+01,
C      1.5240400E+01, 1.5267900E+01, 1.5295400E+01, 1.5322900E+01,
C      1.5350400E+01, 1.5377900E+01, 1.5405400E+01, 1.5432900E+01,
C      1.5460400E+01, 1.5487900E+01, 1.5515400E+01, 1.5542900E+01,
C      1.5570400E+01, 1.5597900E+01, 1.5625400E+01, 1.5652900E+01,
C      1.5680400E+01, 1.5707900E+01, 1.5735400E+01, 1.5762900E+01,
C      1.5790400E+01, 1.5817900E+01, 1.5845400E+01, 1.5872900E+01,
C      1.5900400E+01, 1.5927900E+01, 1.5955400E+01, 1.5982900E+01,
C      1.6010400E+01, 1.6037900E+01, 1.6065400E+01, 1.6092900E+01,
C      1.6120400E+01, 1.6147900E+01, 1.6175400E+01, 1.6202900E+01,
C      1.6230400E+01, 1.6257900E+01, 1.6285400E+01, 1.6312900E+01,
C      1.6340400E+01, 1.6367900E+01, 1.6395400E+01, 1.6422900E+01,
C      1.6450400E+01, 1.6477900E+01, 1.6505400E+01, 1.6532900E+01,
C      1.6560400E+01, 1.6587900E+01, 1.6615400E+01, 1.6642900E+01,
C      1.6670400E+01, 1.6697900E+01, 1.6725400E+01, 1.6752900E+01,
C      1.6780400E+01, 1.6807900E+01, 1.6835400E+01, 1.6862900E+01,
C      1.6890400E+01, 1.6917900E+01, 1.6945400E+01, 1.6972900E+01,
C      1.7000400E+01, 1.7027900E+01, 1.7055400E+01, 1.7082900E+01,
C      1.7110400E+01, 1.7137900E+01, 1.7165400E+01, 1.7192900E+01,
C      1.7220400E+01, 1.7247900E+01, 1.7275400E+01, 1.7302900E+01,
C      1.7330400E+01, 1.7357900E+01, 1.7385400E+01, 1.7412900E+01,
C      1.7440400E+01, 1.7467900E+01, 1.7495400E+01, 1.7522900E+01,
C      1.7550400E+01, 1.7577900E+01, 1.7605400E+01, 1.7632900E+01,
C      1.7660400E+01, 1.7687900E+01, 1.7715400E+01, 1.7742900E+01,
C      1.7770400E+01, 1.7797900E+01, 1.7825400E+01, 1.7852900E+01,
C      1.7880400E+01, 1.7907900E+01, 1.7935400E+01, 1.7962900E+01,
C      1.7990400E+01, 1.8017900E+01, 1.8045400E+01, 1.8072900E+01,
C      1.8100400E+01, 1.8127900E+01, 1.8155400E+01, 1.8182900E+01,
C      1.8210400E+01, 1.8237900E+01, 1.8265400E+01, 1.8292900E+01,
C      1.8320400E+01, 1.8347900E+01, 1.8375400E+01, 1.8402900E+01,
C      1.8430400E+01, 1.8457900E+01, 1.8485400E+01, 1.8512900E+01,
C      1.8540400E+01, 1.8567900E+01, 1.8595400E+01, 1.8622900E+01,
C      1.8650400E+01, 1.8677900E+01, 1.8705400E+01, 1.8732900E+01,
C      1.8760400E+01, 1.8787900E+01, 1.8815400E+01, 1.8842900E+01,
C      1.8870400E+01, 1.8897900E+01, 1.8925400E+01, 1.8952900E+01,
C      1.8980400E+01, 1.9007900E+01, 1.9035400E+01, 1.9062900E+01,
C      1.9090400E+01, 1.9117900E+01, 1.9145400E+01, 1.9172900E+01,
C      1.9200400E+01, 1.9227900E+01, 1.9255400E+01, 1.9282900E+01,
C      1.9310400E+01, 1.9337900E+01, 1.9365400E+01, 1.9392900E+01,
C      1.9420400E+01, 1.9447900E+01, 1.9475400E+01, 1.9502900E+01,
C      1.9530400E+01, 1.9557900E+01, 1.9585400E+01, 1.9612900E+01,
C      1.9640400E+01, 1.9667900E+01, 1.9695400E+01, 1.9722900E+01,
C      1.9750400E+01, 1.9777900E+01, 1.9805400E+01, 1.9832900E+01,
C      1.9860400E+01, 1.9887900E+01, 1.9915400E+01, 1.9942900E+01,
C      1.9970400E+01, 1.9997900E+01, 2.0025400E+01, 2.0052900E+01,
C      2.0080400E+01, 2.0107900E+01, 2.0135400E+01, 2.0162900E+01,
C      2.0190400E+01, 2.0217900E+01, 2.0245400E+01, 2.0272900E+01,
C      2.0300400E+01, 2.0327900E+01, 2.0355400E+01, 2.0382900E+01,
C      2.0410400E+01, 2.0437900E+01, 2.0465400E+01, 2.0492900E+01,
C      2.0520400E+01, 2.0547900E+01, 2.0575400E+01, 2.0602900E+01,
C      2.0630400E+01, 2.0657900E+01, 2.0685400E+01, 2.0712900E+01,
C      2.0740400E+01, 2.0767900E+01, 2.0795400E+01, 2.0822900E+01,
C      2.0850400E+0
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SUBROUTINE VOICOM	74/74	OPT=1	FTL 4.6+428	03/14/78
75	C .2148588E+00, .2217553E+00, .2268657E+00, .2355745E+00,			DL
	C .2424897E+00, .2496878E+00, .2563361E+00, .2632559E+00			00
	C /			00
	DATA (CLO(I), I=41, 80) /			000140
	C .2781850E+00, .2771169E+00, .2840519E+00, .2909883E+00,			008200
80	C .2979271E+00, .3048678E+00, .3118094E+00, .3187523E+00,			008210
	C .3258098E+00, .3326396E+00, .3395835E+00, .3465269E+00,			008220
	C .3534697E+00, .3604113E+00, .3673519E+00, .3742898E+00,			008230
	C .3812258E+00, .3881992E+00, .3950899E+00, .4020163E+00,			008240
	C .4089391E+00, .4158578E+00, .4227712E+00, .4296798E+00,			008250
85	C .4365821E+00, .4434780E+00, .4503688E+00, .4572530E+00,			008260
	C .4641268E+00, .4709918E+00, .4778483E+00, .4846962E+00,			008270
	C .4915762E+00, .4983616E+00, .5051779E+00, .5119822E+00,			008280
	C .5187763E+00, .5255913E+00, .5323187E+00, .5390698E+00			008290
	C /			008300
90	DATA (CLO(I), I=81, 120) /			008310
	C .5458840E+00, .5525262E+00, .5592382E+00, .5659170E+00,			008320
	C .5725868E+00, .5792384E+00, .5858675E+00, .5924784E+00,			008330
	C .5990684E+00, .6056366E+00, .6121823E+00, .6187046E+00,			008340
	C .6245204E+00, .6310756E+00, .6376122E+00, .6441422E+00,			008350
95	C .6509349E+00, .6574844E+00, .6639323E+00, .6699355E+00,			008360
	C .6762872E+00, .6824463E+00, .6886518E+00, .6948228E+00,			008370
	C .7009582E+00, .7070589E+00, .7131180E+00, .7191403E+00,			008380
	C .7241224E+00, .7301866E+00, .7362649E+00, .7423621E+00,			008390
	C .7484337E+00, .7544889E+00, .7605188E+00, .7665951E+00,			008400
100	C .7714198E+00, .7769948E+00, .7825188E+00, .7879908E+00			008410
	C /			008420
	DATA (CLO(I), I=121, 160) /			008430
	C .7934097E+00, .7987743E+00, .8040834E+00, .8093360E+00,			008440
	C .8144389E+00, .8196669E+00, .8247431E+00, .8297583E+00,			008450
105	C .8347114E+00, .8396014E+00, .8444271E+00, .8491676E+00,			008460
	C .8538818E+00, .8585088E+00, .8630675E+00, .8675570E+00,			008470
	C .8719763E+00, .8763246E+00, .8806011E+00, .8848047E+00,			008480
	C .8889749E+00, .8929907E+00, .8969719E+00, .9008766E+00,			008490
	C .9047853E+00, .9086571E+00, .9121302E+00, .9157274E+00,			008500
110	C .9192450E+00, .9226837E+00, .9260431E+00, .9293224E+00,			008510
	C .9325228E+00, .9356426E+00, .9386822E+00, .9416414E+00,			008520
	C .9445203E+00, .9473188E+00, .9500370E+00, .9526751E+00			008530
	C /			008540
	DATA (CLO(I), I=161, 200) /			008550
115	C .9557332E+00, .9577116E+00, .9611105E+00, .9624704E+00,			008560
	C .9644716E+00, .9668346E+00, .9689199E+00, .9709282E+00,			008570
	C .9728594E+00, .9747158E+00, .9764967E+00, .9782032E+00,			008580
	C .9798761E+00, .9813965E+00, .9828850E+00, .9843028E+00,			008590
	C .9856506E+00, .9869297E+00, .9881489E+00, .9892893E+00,			008600
120	C .9903642E+00, .9913784E+00, .9923294E+00, .9932181E+00,			008610
	C .9940498E+00, .9948137E+00, .9955230E+00, .9961749E+00,			008620
	C .9967767E+00, .9973117E+00, .9977999E+00, .9982340E+00,			008630
	C .9986179E+00, .9989519E+00, .9992374E+00, .9994755E+00,			008640
	C .9996676E+00, .9998148E+00, .9999185E+00, .9999788E+00,			008650
125	C 1. /			008660
	RETURN			008670
	END			008680

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SUBROUTINE ABSMR6		74/74	OPT=1	FTN 4, 6+624	03/14/74
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1	SUBROUTINE ABSMR6 (ITYPE, ISMALL, IOLDPL, LFILE, MFILE)	000600
	COMMON FF (P410), DUMF (2410)	010700
	COMMON /MAIN/ KFILE, KPANEL, P0, TEMP0	000710
	COMMON /XABS/ NMOL, XID(7), SECANT, PAVE, TAVE, NMCLID(7), MK(7),	000720
5	C DV, V1, V2, NLMR	000730
	DIMENSION SAVED(5), A1(10), A2(10), A3(10), A4(10)	000740
	COMMON /OPANL/ OV1P, OV2P, ODP, NLMO	000750
	COMMON /NPANL/ V1P, V2P, OWP, NLMN	000760
	ISTOP=0	000770
10	CALL SECONO (TIME)	000780
	PRINT 220, TIME	000790
	IKNL=1	000800
	ISAVE=0	000810
	SAVED(4)=0.	000820
15	C	000830
	C ISMALL=1, IF OV(K-1) IS LESS THAN OV(K)	000840
	C	000850
	IF (ISMALL.EQ.1) GO TO 10	000860
20	IOLD=LFILE	000870
	KNEW=KFILE	000880
	KNL=KPANEL	000890
	GO TO 20	000900
10	KNEW=LFILE	000910
	IOLD=KFILE	000920
25	KAL=IOLDPL	000930
20	RETIME 11	000940
	PRINT*, "MFILE, LFILE, KFILE, KPANEL ", MFILE, LFILE, KFILE, KPANEL	000950
	RETIME 12	000960
	RETIME KFILE	000970
30	SAVED=0.0	000980
	READ (KFILE) (XID(I), I=1, 7), SECANT, PAVE, TAVE, (NMCLID(I), I=1, 7),	000990
	1 (MK(I), I=1, 7), DV, V1, V2, NLMR	001000
	WRITE (MFILE) (XID(I), I=1, 7), SECANT, PAVE, TAVE, (NMCLID(I), I=1, 7),	001010
	1 (MK(I), I=1, 7), DV, V1, V2, NLMR	001020
35	READ (LFILE) XID(1), XID(2)	001030
	BUFFER IN (KFILE, 1) (XID(1), XID(2))	001040
	IF (UNIT (MFILE) .EQ. 0) STOP " 2"	001050
40	400 BUFFER OUT (MFILE, 1) (XID(1), NLMR)	001060
	IF (UNIT (MFILE) .EQ. 0) STOP " 1"	001070
	420 BUFFER IN (LFILE, 1) (XID(1), NLMR)	001080
	IF (UNIT (LFILE) .EQ. 0) STOP " 3"	001090
200	DO 30 K=1, 5	001100
30	SAVED(K)=0.	001110
	ATYPE=ITYPE	001120
45	AP=1.0/(ATYPE+1.0)	001130
	IF (ITYPE .NE. 0) GO TO 430	001140
	C	001150
	C 1/2 RATIO ONLY	001160
	C	001170
50	DO 435 KOD=1, KNL	001180
	BUFFER IN (IOLD, 1) (OV1P, NLMO)	001190
	IF (UNIT (IOLD) .EQ. 0) STOP " 12"	001200
	BUFFER IN (IOLD, 1) (DUMF(1), DUMF (NLMO))	001210
	IF (UNIT (IOLD) .EQ. 0) STOP " 13"	001220
55	BUFFER IN (KNEW, 1) (V1P, NLMN)	001230
	IF (UNIT (KNEW) .EQ. 0) STOP " 14"	001240
	BUFFER IN (KNEW, 1) (FF(1), FF (NLMN))	001250
	IF (UNIT (KNEW) .EQ. 0) STOP " 15"	001260
	DO 440 KOD=1, NLMN	001270
60	440 FF(KOD)=FF(KOD)+DUMF(KOD)	001280
	BUFFER OUT (MFILE, 1) (V1P, NLMN)	001290
	IF (UNIT (MFILE) .EQ. 0) STOP " 16"	001300
	BUFFER OUT (MFILE, 1) (FF(1), FF (NLMN))	001310
	IF (UNIT (MFILE) .EQ. 0) STOP " 17"	001320
65	435 CONTINUE	001330
	GO TO 210	001340
	C	001350
	C ALL RATIOS EXCEPT 1/2	001360
	C	001370
70	430 LL=ITYPE+1	001380
	DO 40 JPG=1, ITYPE	001390
	APG=JPG	001400
	P=1.0-(AP*APG)	001410

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SUBROUTINE ABSMRG

74/74 OPT=1

FTN 4.6+428

03/14/78

73	C	009420
	C***** THE FOLLOWING ARE THE CONSTANTS FOR THE LAGRANGE 4 POINT	009430
	C INTERPOLATION. *****	009440
	C	009450
	A1(JPG)=-P*(P-1.0)*(P-2.0)/6.0	009460
	A2(JPG)=(P**2-1.0)*(P-2.0)*0.5	009470
80	A3(JPG)=-P*(P+1.0)*(P-2.0)*0.5	009480
	A4(JPG)=P*(P**2-1.0)/6.0	009490
	40 CONTINUE	009500
	C	009510
	C ***** BEGINNING OF LOOP THAT DOES ADDITION *****	009520
85	C	009530
	\$ READ(IOLD) OV1P,OV2P,ODVPP,NLIMO	009540
	\$ BUFFER IN(IOLD,1) (OV1P,NLIMO)	009550
	\$ IF(UNIT(IOLD) .EQ. 0) STOP " 4"	009560
	\$ REAC(IOLD) (DUMF(J),J=1,NLIMO)	009570
90	310 BUFFER IN(IOLD,1) (DUMF(1),DUMF(NLIMO))	009580
	\$ IF(UNIT(IOLD) .EQ. 0) STOP " 5"	009590
	320 NVS=1	009600
	\$ READ(KNEW) V1P,V2P,DVP,NLIM	009610
	\$ BUFFER IN(KNEW,1) (V1P,NLIM)	009620
95	\$ IF(UNIT(KNEW) .EQ. 0) STOP " 6"	009630
	\$ REAC(KNEW) (FF(J),J=1,NLIM)	009640
	330 BUFFER IN(KNEW,1) (FF(1),FF(NLIM))	009650
	\$ IF(UNIT(KNEW) .EQ. 0) STOP " 7"	009660
	340 FF(1)=FF(1)+DUMF(1)	009670
100	II=2	009680
	60 JJ=1	009690
	DO 170 JPG=1,LL	009700
	IF (JPG.EQ.LL) GO TO 70	009710
	IF (NVS.FO.1) GO TO 80	009720
105	GO TO 90	009730
	70 FF(II)=FF(II)+DUMF(NVS)	009740
	GO TO 110	009750
	80 IF (SAVEDD(4) .EQ. 0.0) GO TO 81	009760
	DUMFY=SAVEDD(4)	009770
110	GO TO 100	009780
	81 DUMFY=DUMF(1)	009790
	GO TO 100	009800
	90 DUMFY=DUMF(NVS-1)	009810
100	FF(II)=FF(II)+A1(JJ)*DUMFY+A2(JJ)*DUMF(NVS)+A3(JJ)*DUMF(NVS+1)+A4(JJ)*DUMF(NVS+2)	009820
115	110 NVS=NVS+1	009830
	IF (NVS.LE.NLIMO-2) GO TO 140	009840
	SAVEDD(1)=DUMF(NVS-1)	009850
	SAVEDD(2)=DUMF(NVS)	009860
120	SAVEDD(3)=DUMF(NVS+1)	009870
	SAVEDD(4)=DUMF(NVS+2)	009880
	\$ READ(IOLD) OV1P,OV2P,ODVPP,NLIMO	009890
	\$ IF (EOF(IOLD)) 120,120	009900
	\$ BUFFER IN(IOLD,1) (OV1P,NLIMO)	009910
125	\$ IF (UNIT(IOLD)) 120,120,120	009920
	120 NLIMO=NLIMO+3	009930
	\$ READ(IOLD) (DUMF(J),J=1,NLIMO)	009940
	\$ IF (EOF(IOLD)) 120,130	009950
	\$ BUFFER IN(IOLD,1) (DUMF(4),DUMF(NLIMO))	009960
130	\$ IF (UNIT(IOLD)) 130,120,130	009970
	130 DUMF(1)=SAVEDD(1)	009980
	DUMF(2)=SAVEDD(2)	009990
	DUMF(3)=SAVEDD(3)	010000
	NVS=2	010010
135	140 II=II+1	010020
	JJ=JJ+1	010030
	IF (II.GT.NLIM) GO TO 150	010040
	GO TO 170	010050
140	150 II=II+1	010060
	AVRG=(SAVEDD(1)+SAVEDD(2))*0.5	010070
200	FF(II)=FF(II)+AVRG	010080
	II=II+1	010090
	IF (II .LE. NLIM) GO TO 200	010100
		010110

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SUBROUTINE ADDRESS	74/74	OPT=1	FTN 4.6+426	03/14/78
145	C			010125
	C WRITE OUTPUT FILE			010130
	C			010140
	2150 WRITE(MFILE) V1P,V2P,DVP,NLIM			010150
	8 WRITE(MFILE) (FF(J),J=1,NLIM)			010160
	150 BUFFER OUT(MFILE,1) (V1P,NLIM)			010170
155	IF (UNIT(MFILE) .EQ. 0) STOP " 0"			010180
	370 BUFFER OUT(MFILE,1) (FF(1),FF(NLIM))			010190
	IF (UNIT(MFILE) .EQ. 0) STOP " 0"			010200
	380 INKL=INML+1			010210
	IF (INML.LE.KNL) GO TO 160			010220
	GO TO 210			010230
155	8 READ(KNEW) V1P,V2P,DVP,NLIM			010240
	160 BUFFER IN(KNEW,1) (V1P,NLIM)			010250
	IF (UNIT(KNEW) .EQ. 0) STOP " 10"			010260
	8 READ(KNEW) (FF(J),J=1,NLIM)			010270
160	390 BUFFER IN(KNEW,1) (FF(1),FF(NLIM))			010280
	IF (UNIT(KNEW) .EQ. 0) STOP " 11"			010290
	360 II=1			010300
	170 CONTINUE			010310
	NVS=NVS-1			010320
165	GO TO 60			010330
	210 REWIND KFILE			010340
	C			010350
	CALL SECOND (TIME1)			010360
	TIME=TIME1-TIME			010370
170	PRINT 240, TIME1,TIME			010380
	RETURN			010390
	C			010400
	C			010410
	C			010420
175	220 FORMAT ('0 THE TIME AT THE START OF ARSHRG IS ',F12.3)			010430
	240 FORMAT ('0 THE TIME AT THE END OF ARSHRG IS ',F12.3/'F12.3, SECS ME			010440
	1RE REQUIRED FOR THIS ADDITION')			010450
	END			010460

SUBROUTINE EMINIT	74/74	OPT=1	FTN 4.6+426	03/14/78
1	SUBROUTINE EMINIT(ILOOK,TBOUND,MFILE)			010470
	COMMON EMISS(2410),DOCTES(101),FF(2410),EDGE(101)			010480
	COMMON/MAIN/ KFILE,KPANEL,P0,TEMP0			010490
	COMMON/NEW/ NMOL,KID(7),SECANT,PAVE,TAVE,NMOLIO(7),WK(7),			010500
5	OV,V1,V2,NLAYER			010510
	COMMON /OPANL/ OV1P,OV2P,ODVP,NLIMO			010520
	C			010530
	C *****			010540
	C ***** THIS SUBROUTINE COMPUTES THE EMISSION FOR THE FIRST LAYER *****			010550
10	C *****			010560
	C			010570
	C TBOUND IS A TEMPERATURE USED IN COMPUTING A BLACK BODY WHICH			010580
	C WILL BE USED AS A BOUNDARY.			010590
	C			010600
15	EXPF(Y)=EXP(AMAX1(-174.0,Y))			010610
	BBODY(X)=(1.1914E-12*X**3)/(EXPF(1.43789*X/TAVE)-1.0)			010620
	BOUND(X)=(1.1910E-12*X**3)/(EXPF(1.43789*X/TBOUND)-1.0)			010630
	PRINT *, " EMINIT, MFILE, KFILE ", MFILE,KFILE			010640
	CALL SECOND(TIME)			010650
20	IT=0.0			010660
	RENAME KFILE			010670
	8 READ(KFILE) (KID(I),I=1,7),SECANT,PAVE,TAVE,(NMOLIO(I),I=1,7),			010680
	1(WK(I),I=1,7),OV,V1,V2,NLAYER			010690
	8 WRITE(MFILE) (KID(I),I=1,7),SECANT,PAVE,TAVE,(NMOLIO(I),I=1,7),			010700
25	1(WK(I),I=1,7),OV,V1,V2,NLAYER			010710
	BUFFER IN(MFILE,1) (KID(1),NLAYER)			010720
	IF (UNIT(KFILE) .EQ. 0) STOP			010730
	BUFFER OUT(MFILE,1) (KID(1),NLAYER)			010740
	IF (UNIT(MFILE) .EQ. 0.) STOP			010750
30	DO 1 II=1,KPANEL			010760
	8 READ(KFILE) OV1P,OV2P,ODVP,NLIMO			010770

ROUTINE	ENHIT	76/76	OPT=1	PTM 4.6-420	02/14/76
					010700
					010700
					010800
35					010810
					010820
					010830
270					010840
					010850
40					010860
					010870
40					010880
					010890
					010900
45					010910
					010920
					010930
					010940
50					010950
280					010960
290					010970
					010980
					010990
55					011000
					011010
					011020
					011030
					011040
60					011050
20					011060
					011070
					011080
					011090
65					011100
					011110
					011120
					011130
					011140
70					011150
					011160
					011170
					011180
					011190
75					011200
35					011210
					011220
					011230
					011240
80					011250
					011260
					011270
					011280
					011290
85					011300
					011310
					011320
					011330
					011340
					011350
90					011360
					011370
					011380
					011390
					011400
95					011410
					011420
					011430
					011440
					011450
100					011460
					011470

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SUBROUTINE EMUP      74/74  OPT=1      FTH 4.6+428      03/14/78

1      SUBROUTINE EMUP(INPTS,ITYPE,LFILE,MFILE)      011480
COMMON      OLDEM(2410),OLOTR(2410),NEWEM(2410)      011490
COMMON/MAIN/ KFILE,KPANEL,P0,TEMP0      011500
COMMON/HEMIS/      NMOL,XIO(7),SECANT,PAVE,TAVE,NMOLIO(7),WK(7),      011510
5      C      7V,V1,V2,NLAYER      011520
COMMON /OPANL/ OV1P,OV2P,OV3P,NLINO      011530
DIMENSION EMSAVE(4),A1(10),A2(10),A3(10),A4(10),TRSAVE(4)      011540
DIMENSION TR(2410),NEWTR(1),BOODIES(101)      011550
COMMON /NPANL/ V1P,V2P,OV3P,NLIN      011560
10      EQUIVALENCE (TR(1),NEWTR(1))      011570
REAL NEWEM,NEWTR      011580
C      011590
C *****      011600
C ***** THIS SUBROUTINE DOES THE LAYER ADDITION FOR THE EMISSION *****      011610
C      LOOKING FROM GROUND TO SPACE.      011620
C *****      011630
C      011640
EXPFF(V)=EXP(AMAX1(-174.0,V))      011650
BOODY(X)=(1.1916E-12*X**3)/(EXPFF(1.43789*X/TAVE)-1.0)      011660
EXPINH=EXP(-174.0)      011670
CALL SECOND(TIME)      011680
PRINT *, " EMUP, MFILE, LFILE, KFILE ", MFILE,LFILE,KFILE      011690
PRINT 220,TIME      011700
IKKL=1      011710
25      PRINT *, " THIS OUTPUT IS WRITTEN ON FILE ",MFILE      011720
C      011730
KML=KPANEL      011740
20      REMIND MFILE      011750
REIND LFILE      011760
30      REIND MFILE      011770
BUFFER IN (LFILE,1) (XIO(1),XIO(2))      011780
IF (UNIT(LFILE) .EQ. 0) STOP      011790
BUFFER IN(KFILE,1)(XIO(1),NLAYER)      011800
IF(UNIT(KFILE) .EQ. 0) STOP      011810
35      BUFFER OUT(MFILE,1)(XIO(1),NLAYER)      011820
IF(UNIT(MFILE) .EQ. 0) STOP      011830
DO 30 K=1,4      011840
EMSAVE(K)=0.      011850
TSAVE(K)=0.      011860
40      ATYPE=ITYPE      011870
IF(ITYPE .NE. 0) GO TO 430      011880
C      011890
C 1/1 RATIO ONLY      011900
C      011910
45      JUG=3      011920
JOG=2      011930
GO TO 360      011940
55      BUFFER IN(LFILE,1)(OV1P,NLINO)      011950
IF(UNIT(LFILE) .EQ. 0) STOP      011960
50      BUFFER IN(LFILE,1)(OLDEM(1),OLOEM(NLINO))      011970
IF(UNIT(LFILE) .EQ. 0) STOP      011980
BUFFER IN(LFILE,1)(OLOTR(1),OLOTR(NLINO))      011990
IF(UNIT(LFILE) .EQ. 0) STOP      012000
NO 550 J=1,NLIN      012010
NEWEM(J)=OLOEM(J)+(1.0-TR(J))*BOOLOTR(J)      012020
NEWTR(J)=TR(J)*OLOTR(J)      012030
TESTER=TESTER+OV3P      012040
IF(TESTER .LT. CHANGE) GO TO 530      012050
CONCH=CHANGE-ROD      012060
BO=BOODIES(LTEST)-(BOODIES(LTEST)-BOODIES(LTEST+1))*CONCH      012070
CHANGE=CHANGE+OV3P      012080
IF(CHANGE .GE. BOD+1.0) GO TO 560      012090
GO TO 530      012100
560      LTEST=LTEST+1      012110
BOO=BOO+1.0      012120
65      530 CONTINUE      012130
GO TO 180      012140
550      IKKL=IKKL+1      012150
IF(IKKL .LE. KML) GO TO 360      012160
70      GO TO 210      012170
C      012180
C ALL RATIOS EXCEPT 1/1      012190
C      012200
430      LL=ITYPE+1      012210

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SUBROUTINE ENUP	74/74 OPT=1	FTN 4.6-428	03/14/78
75	AP=1.0/(ATYPE+1.0)		012220
	JOG=1		012230
	DO 48 JPC=1, IYPE		012240
	APG=JPC		012250
	P=1.0-(AP*APG)		012260
80	PRINT *, " P= ", P		012270
	C		012280
	C ***** THE FOLLOW ARE THE CONSTANTS FOR THE LAGRANGE 4 PCINT		012290
	C ***** INTERPOLATION		012300
	C		012310
85	A1(JPC)=P*(P-1.0)*(P-2.0)/6.0		012320
	A2(JPC)=(P**2-1.0)*(P-2.0)*8.0		012330
	A3(JPC)=P*(P+1.0)*(P-2.0)*8.0		012340
	A4(JPC)=P*(P**2-1.0)/6.0		012350
	40 CONTINUE		012360
90	C		012370
	C ***** BEGINNING OF LOOP THAT DOES ADDITION *****		012380
	C		012390
	JUG=1		012400
	READ(LFILE) OV1P, OV2P, OOV, NLIMO		012410
95	BUFFER IN(LFILE, 1) (OV1P, NLIMO)		012420
	IF(UNIT(LFILE) .EQ. 8) STOP		012430
	C		012440
	C NEMEM IS THE REGION FOR THE EMISSION SUMMATION		012450
	C		012460
100	READ(LFILE) (OLDEN(I), J=1, NLIMO)		012470
	BUFFER IN(LFILE, 1) (OLDEN(1), OLDEN(NLIMO))		012480
	IF(UNIT(LFILE) .EQ. 8) STOP		012490
	C		012500
	C NEMTR IS THE REGION FOR THE TRANSMISSION SUMMATION		012510
105	C		012520
	BUFFER IN(LFILE, 1) (OLDTR(1), OLDTR(NLIMO))		012530
	IF(UNIT(LFILE) .EQ. 8) STOP		012540
	NVS=1		012550
	GO TO 360		012560
110	340 NEMEM(1)=OLDEN(1)+(1.0-TR(1))*BR*OLDTR(1)		012570
	NEMTR(1)=TR(1)*OLDTR(1)		012580
	TESTER=TESTER+DVP		012590
	II=2		012600
	60 JJ=1		012610
115	C		012620
	C		012630
	DO 190 JPC=1, LL		012640
	IF(JPC .EQ. LL) GO TO 70		012650
	IF(NVS .EQ. 1) GO TO 80		012660
120	GO TO 90		012670
	70 NEMEM(II)=OLDEN(NVS)+(1.0-TR(II))*BR*OLDTR(NVS)		012680
	NEMTR(II)=TR(II)*OLDTR(NVS)		012690
	TESTER=TESTER+DVP		012700
	GO TO 110		012710
125	80 IF(EMSAVE(4) .EQ. 0.0) GO TO 81		012720
	EMSTOR=EMSAVE(4)		012730
	TRSTOR=TRSAVE(4)		012740
	GO TO 180		012750
	81 EMSTOR=OLDEN(1)		012760
130	TRSTOR=OLDTR(1)		012770
	GO TO 180		012780
	90 EMSTOR=OLDEN(NVS-1)		012790
	TRSTOR=OLDTR(NVS-1)		012800
	C		012810
135	C INTERPOLATE FOR THE OLD EMISSION		012820
	C		012830
140	OLDENI=A1(JJ)*EMSTOR+A2(JJ)*OLDEN(NVS)+A3(JJ)*OLDEN(NVS+1)+		012840
	A4(JJ)*OLDEN(NVS+2)		012850
	C		012860
	C INTERPOLATE FOR THE OLD TRANSMISSION		012870
	C		012880
	OLDTRI=A1(JJ)*TRSTOR+A2(JJ)*OLDTR(NVS)+A3(JJ)*OLDTR(NVS+1)+		012890
	A4(JJ)*OLDTR(NVS+2)		012900
	NEMEM(II)=OLDENI+(1.0-TR(II))*BR*OLDTRI		012910
145	NEMTR(II)=TR(II)*OLDTRI		012920
	TESTER=TESTER+DVP		012930
	NVS=NVS+1		012940
	IF(NVS .LE. NLIMO-2) GO TO 140		012950
	EMSAVE(1)=OLDEN(NVS-1)		012960

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SUBROUTINE EMUP	74/74	OPT=1	FTM 4.6+428	03/16/78
150	EMSAVE(2)=OLDEM(NVS)			012970
	EMSAVE(3)=OLDEM(NVS+1)			012980
	EMSAVE(4)=OLDEM(NVS-2)			012990
	TRSAVE(1)=OLDTR(NVS-1)			013000
	TRSAVE(2)=OLDTR(NVS)			013010
155	TRSAVE(3)=OLDTR(NVS+1)			013020
	TRSAVE(4)=OLDTR(NVS-2)			013030
	READ(LFILE) OV1P,OV2P,OV3P,NLINO			013040
	IF(FOF(LFILE)) 180,120			013050
	BUFFER IN(LFILE,1)(OV1P,NLINO)			013060
160	IF(UNIT(LFILE)) 120,180,120			013070
	120 NLINO=NLINO+3			013080
	READ(LFILE)(OLDEM(J),J=4,NLINO)			013090
	BUFFER IN(LFILE,1)(OLDEM(4),OLDEM(NLINO))			013100
	IF(UNIT(LFILE)) 130,180,130			013110
165	READ(LFILE)(OLDTR(J),J=4,NLINO)			013120
130	BUFFER IN(LFILE,1)(OLDTR(4),OLDTR(NLINO))			013130
	IF(UNIT(LFILE)) .EQ. 0) STOP			013140
	OLDEM(1)=EMSAVE(1)			013150
	OLDEM(2)=EMSAVE(2)			013160
170	OLDEM(3)=EMSAVE(3)			013170
	OLDTR(1)=TRSAVE(1)			013180
	OLDTR(2)=TRSAVE(2)			013190
	OLDTR(3)=TRSAVE(3)			013200
	NVS=2			013210
175	140 II=II+1			013220
	JJ=JJ+1			013230
	IF(II .GT. NLIN) GO TO 180			013240
	GO TO 170			013250
	C			013260
180	C AN EOF HAS OCCURED ON THE FILE FOR THE PREVIOUS LAYER			013270
	C			013280
	180 II=II+1			013290
	EM1=(EMSAVE(3)+EMSAVE(2))*0.5			013300
	TR1=(TRSAVE(3)+TRSAVE(2))*0.5			013310
185	200 NEHEM(J)=EM1+(1.0-TR1)*BB*TR1			013320
	NEWTR(J)=TR1			013330
	II=II+1			013340
	IF(II .LE. NLIN) GO TO 200			013350
190	WRITE(MFILE) V1P,V2P,DV,NLIM			013360
	WRITE(MFILE) (NEHEM(J),J=1,NLIM)			013370
	WRITE(MFILE) (NEWTR(J),J=1,NLIM)			013380
	C			013390
	C WRITE OUTPUT FILE			013400
	C			013410
195	150 BUFFER OUT(MFILE,1)(V1P,NLIM)			013420
	IF(UNIT(MFILE)) .EQ. 0) STOP			013430
	BUFFER OUT(MFILE,1)(NEHEM(1),NEHEM(NLIM))			013440
	IF(UNIT(MFILE)) .EQ. 0) STOP			013450
	BUFFER OUT(MFILE,1)(NEWTR(1),NEWTR(NLIM))			013460
200	IF(UNIT(MFILE)) .EQ. 0) STOP			013470
	IF (NPTS .LE. 0) GO TO 330			013480
	DO 320 J=1,NPTS			013490
	VP=V1P+FLOAT(J-1)*DVP			013500
205	320 PRINT 900, J,VP,NEHEM(J),NEWTR(J)			013510
	JEND=NLIM-NPTS+1			013520
	DO 330 J=JEND,NLIM			013530
	VP=V1P+FLOAT(J-1)*DVP			013540
	330 PRINT 900, J,VP,NEHEM(J),NEWTR(J)			013550
	900 FORMAT(110,F12.6,3E15.8)			013560
210	375 CONTINUE			013570
	GO TO (545,550),JOG			013580
	545 IKNL=IKNL+1			013590
	IF(IKNL .LE. KNL) GO TO 160			013600
	GO TO 210			013610
215	160 JUS=2			013620
	360 BUFFER IN(KFILE,1)(V1P,NLIM)			013630
	IF(UNIT(KFILE)) .EQ. 0) STOP			013640
	BUFFER IN(KFILE,1)(TR1,TR(NLIM))			013650
	IF(UNIT(KFILE)) .EQ. 0) STOP			013660
220	C			013670
	C COMPUTE THE BLACK BODY EVERY 1 WAVE # BEGINNING AT V1P			013680
	C			013690

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SUBROUTINE ENUP	74/74	OPT=1	PTM 4.6+428	03/14/78
		BEGIN=VIP		013700
		ROC=BEGIN		013710
225		I=1		013720
	270	RODIES(I)=BODY(BEGIN)		013730
		I=I+1		013740
		IF(I.GT. 101) STOP		013750
		BEGIN=BEGIN+1.0		013760
230		IF(BEGIN.LE. V2P+1.0) GO TO 270		013770
		IF(I.EQ. 2) RODIES(2)=RODIES(1)		013780
		COMMON=1.44*VIP/TAVE		013790
		IF(COMMON.LE. 4.005) GO TO 280		013800
		DENOM=1.		013810
235		GO TO 290		013820
	280	DENOM=1.0-EXP(-COMMON)		013830
	290	DVMBF=VIP*1.0E-4/ABS(3.0-(COMMON/DENOM))		013840
	CCC	PRINT *,(RODIES(LUD),LUD)=1.01)		013850
		BB=RODIES(1)		013860
240		TESTER=VIP		013870
		CHANGE=VIP+DVMBF		013880
		LTEST=1		013890
		DO 260 J=1,NLIN		013900
		TRJ=TR(J)		013910
245		TR(J)=1.		013920
		IF (TRJ.LE. 0.) GO TO 260		013930
		IF (TRJ.LT. 174.0) GO TO 250		013940
		TR(J)=EXP(MIN		013950
		GO TO 260		013960
250	250	TR(J)=EXP(-TRJ)		013970
	260	CONTINUE		013980
		GO TO (340,350,535),JUR		013990
	350	II=1		014000
	170	IF(TESTER.LT. CHANGE) GO TO 190		014010
255		COMMON=CHANGE-BOD		014020
		BB=RODIES(LTEST)-(RODIES(LTEST)-RODIES(LTEST+1))*COMMON		014030
		CHANGE=CHANGE+DVMBF		014040
		IF(CHANGE.GE. BOD+1.0) GO TO 300		014050
		GO TO 190		014060
260	300	LTEST=LTEST+1		014070
		ROD=ROD+1.0		014080
	190	CONTINUE		014090
		NVS=NVS-1		014100
	C			014110
265		GO TO 60		014120
	210	REWIND KFILE		014130
	C			014140
		CALL SECOND(TIME1)		014150
		TIM=TIME1-TIME		014160
270		PRINT 240,TIME1,TIM		014170
		RETURN		014180
	C			014190
	C			014200
	C			014210
275	220	FORMAT('0 THE TIME AT THE START OF ENUP IS ',F12.3)		014220
	240	FORMAT('0 THE TIME AT THE END OF ENUP IS ',F12.3/		014230
		1* SECS WERE REQUIRED FOR THIS ADDITION')		014240
	C			014250
		END		014260

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SUBROUTINE ENDDOWN 74/74 OPT=1 PTH 4.6+420 03/14/78

1      SUBROUTINE ENDDOWN(NPTS, IYPE, LFILE, MFILE)
      COMMON OLDEM(2410), OLCTR(2410), NEMEN(2410)
      COMMON/MAIN/ KFILE, KPANEL, P0, TEMPO
      COMMON/KEHSS/ MMOL, XID(7), SECANT, PAVE, TAVE, MMOLIO(7), MK(7),
2      DV, V1, V2, NLAVER
      COMMON /OPANL/ OVIP, OV2P, OOV, NLI=0
      COMMON /NPANL/ VIP, V2P, OVP, NLI=0
      DIMENSION ENSAVE(4), A1(10), A2(10), A3(10), A4(10), TRSAVE(4)
      DIMENSION TR(2410), NEMTR(1), BODIES(101)
10     EQUIVALENCE (TR(1), NEMTR(1))
      REAL NEMEN, NEMTR
      C
      C *****
      C ***** THIS SUBROUTINE DOES THE LAYER ADDITION FOR THE EMISSION *****
15     C ***** LOOKING FROM SPACE TO GROUND *****
      C *****
      C
      EXPF(Y)=EXP(ANAK1(-174.0,Y))
      BODY(X)=(1.1918E-12*X**3)/(EXPF(1.43789*X/TAVE)-1.0)
      EXPHI=EXP(-174.0)
      CALL SECOND(TIME)
      PRINT 220, TIME
      IKNL=1
      PRINT *, " THIS OUTPUT IS WRITTEN ON FILE ", MFILE
25     C
      PRINT *, " ENDDOWN, MFILE, LFILE, KFILE ", MFILE, LFILE, KFILE
      KNL=KPANEL
      20     REMIND MFILE
      REMIND LFILE
      30     REMIND KFILE
      BUFFER IN(LFILE, 1) (XID(1), XID(2))
      IF (UNIT(LFILE) .EQ. 0) STOP
      BUFFER IN(KFILE, 1) (XID(1), NLAVER)
      IF (UNIT(KFILE) .EQ. 0) STOP
      BUFFER CUT(MFILE, 1) (XID(1), NLAVER)
      IF (UNIT(MFILE) .EQ. 0) STOP
      DO 30 K=1,4
      TRSAVE(K)=0.
      30     ENSAVE(K)=0.
      40     ATYPE=IYPE
      IF (IYPE .NE. 0) GO TO 430
      C
      C 1/1 RATIO ONLY
      C
      45     JUG=3
      JOG=2
      GO TO 360
      BUFFER IN(LFILE, 1) (OVIP, NLI=0)
      IF (UNIT(LFILE) .EQ. 0) STOP
      50     BUFFER IN(LFILE, 1) (OLDEM(1), OLDEM(NLI=0))
      IF (UNIT(LFILE) .EQ. 0) STOP
      BUFFER IN(LFILE, 1) (OLCTR(1), OLCTR(NLI=0))
      IF (UNIT(LFILE) .EQ. 0) STOP
      DO 550 I=1, NLI
      NEM(I)=TR(I)*OLDEM(I)+(1.0-TR(I))*OB
      NEMTR(I)=TR(I)*OLCTR(I)
      TESTER=TESTER+OVP
      IF (TESTER .LT. CHANGE) GO TO 530
      CHANGE=CHANGE+OVP
      60     BODIES(1TEST)=BODIES(1TEST)+BODIES(1TEST+1)*CONCH
      CHANGE=CHANGE+OVP
      IF (CHANGE .GE. ROD+1.0) GO TO 560
      GO TO 530
      560     1TEST=1TEST+1
      65     ROD=ROD+1.0
      530     CONTINUE
      GO TO 190
      550     IKNL=IKNL+1
      IF (IKNL .LE. KNL) GO TO 360
      70     GO TO 210
      C
      C ALL RATIOS EXCEPT 1/1
      C
      430     LL=IYPE+1
      JOG=1
      75

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SUBROUTINE ENDOCN      74/74    OPT=1      FTM 4.6+428      03/14/78

      AP=1.0/(ATYP*1.0)
      DO 40 JPS=1,ITYPE
      APS=JPS
      P=1.0-(AP*APS)
      PRINT *, " P= ",P
05      C ITYPE IS THE NUMERATOR OF THE RATIO OF OLDV TO NEWV WHICH IS CLOSEST
      C TO A 1/1,2/1,3/1 ETC TO 20/1. P EQUALS THE RECIPROCAL OF THIS RATIO.
      C ***** THE FOLLOWING ARE THE CONSTANTS FOR THE LAGRANGE 4 POINT I
      C INTERPOLATION *****
      A1(JPS)=P*(P-1.0)*(P-2.0)/6.0
      A2(JPS)=(P+2-1.0)*(P-2.0)*0.5
      A3(JPS)=P*(P+1.0)*(P-2.0)*0.5
      A4(JPS)=P*(P+2-1.0)/6.0
60      40 CONTINUE

      C ***** BEGINNING OF LOOP THAT DOES ADDITION *****
      C
      JUS=1
95      S READ(LFILE) OV1P,OV2P,ODVP,NLIMO
      BUFFER IN(LFILE,1)(CV1P,NLIMO)
      IF(UNIT(LFILE).EQ.0) STOP
      C TRANSMISSION AT THE PRESENT LAYER
      C
100     S READ(LFILE)(OLDEN(J),J=1,NLIMO)
      400 BUFFER IN(LFILE,1)(OLDEN(1),OLDEN(NLIMO))
      IF(UNIT(LFILE).EQ.0) STOP
      BUFFER IN(LFILE,1)(OLDTR(1),OLDTR(NLIMO))
105     IF(UNIT(LFILE).EQ.0) STOP
      300 NVS=1
      GO TO 700
      340 NEWEN(1)=TR(1)*OLDEN(1)+(1.0-TR(1))*BB
      NEWTR(1)=TR(1)*OLDTR(1)
110     TESTR=TESTR+DVP
      II=2
      60 JJ=1
      C
      C
115     DO 100 JPS=1,LL
      IF(JPS.EQ.11) GO TO 70
      IF(NVS.EQ.1) GO TO 40
      GO TO 40
      70 NEWEN(II)=TR(II)*OLDEN(NVS)+(1.0-TR(II))*BB
      NEWTR(II)=TR(II)*OLDTR(NVS)
      TESTR=TESTR+DVP
      GO TO 110
      80 IF(ENSAVE(4).EQ.0.0) GO TO 61
      ENSTOP=ENSAVE(4)
      TRSTOP=TRSAVE(4)
125     GO TO 100
      61 ENSTOP=OLDEN(1)
      TRSTOP=OLDTR(1)
      GO TO 100
      71 ENSTOP=OLDEN(NVS-1)
      TRSTOP=OLDTR(NVS-1)
130     C
      C INTERPOLATION OF THE PRESENT TRANSMISSION
      C
135     100 OLDENI=A1(JJ)*ENSTOP+A2(JJ)*OLDEN(NVS)+A3(JJ)*OLDEN(NVS+1)+
      I A4(JJ)*OLDEN(NVS+2)
      OLDTRI=A1(JJ)*TRSTOP+A2(JJ)*OLDTR(NVS)+A3(JJ)*OLDTR(NVS+1)+
      I A4(JJ)*OLDTR(NVS+2)
      NEWEN(II)=(1.0-TR(II))*BB+TR(II)*OLDENI
      NEWTR(II)=TR(II)*OLDTRI
      TESTR=TESTR+DVP
140     NVS=NVS+1
      IF(NVS.LE.NLIMO-2) GO TO 140
      ENSAVE(1)=OLDEN(NVS-1)
      ENSAVE(2)=OLDEN(NVS)
      ENSAVE(3)=OLDEN(NVS+1)
      ENSAVE(4)=OLDEN(NVS+2)
      TRSAVE(1)=OLDTR(NVS-1)
      TRSAVE(2)=OLDTR(NVS)
      TRSAVE(3)=OLDTR(NVS+1)
150

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SUBROUTINE EMBOWN

74/74 OPT=1

FTN 4.0+428

03/14/78

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      TRSAVE(4)=OLDTR(NVS-2)
      READ(LFILE) OV1P,OV2P,OV3P,NLIM
      IF(EOF(LFILE)) 180,120
      BUFFER IN(LFILE,1)(OV1P,NLIM)
180  IF(UNIT(LFILE)) 120,180,180
      NLIM=NLIM+3
      READ(LFILE)(OLDEN(J),J=4,NLIM)
      BUFFER IN(LFILE,1)(OLDEN(4),OLDEN(NLIM))
      IF(UNIT(LFILE)) 42,180,180
180  42  BUFFER IN(LFILE,1)(OLDTR(4),OLDTR(NLIM))
      IF(UNIT(LFILE)) 42,180,180
      OLDEN(1)=EMSAVE(1)
      OLDEN(2)=EMSAVE(2)
      OLDEN(3)=EMSAVE(3)
      OLDTR(1)=TRSAVE(1)
      OLDTR(2)=TRSAVE(2)
      OLDTR(3)=TRSAVE(3)
      NVS=2
140  II=II+1
      JJ=JJ+1
170  IF(II.GT. NLIM) GO TO 150
      GO TO 170
C
C AN EOF HAS OCCURED ON THE FILE FOR THE PREVIOUS LAYER
C
175  180  II=II+1
      EN1=(EMSAVE(3)+EMSAVE(2))*0.5
      TR1=(TRSAVE(3)+TRSAVE(2))*0.5
180  NEWEM(II)=(1.0-TR(II))*0.5+TR(II)*EN1
      NEWTR(II)=TR1+TR(II)
      II=II+1
      IF(II.LE. NLIM) GO TO 200
C
C WRITE OUTPUT FILE
C
185  190  WRITE(MFILE) V1P,V2P,OV,NLIM
      WRITE(MFILE)(NEWEM(J),J=1,NLIM)
      WRITE(MFILE)(NEWTR(J),J=1,NLIM)
      190  BUFFER OUT(MFILE,1)(V1P,NLIM)
      IF(UNIT(MFILE).EQ. 0) STOP
      BUFFER OUT(MFILE,1)(NEWEM(1),NEWEM(NLIM))
      IF(UNIT(MFILE).EQ. 0) STOP
      BUFFER OUT(MFILE,1)(NEWTR(1),NEWTR(NLIM))
      IF(UNIT(MFILE).EQ. 0) STOP
195  IFIVE=5
      IF(NLIM.EQ. 5) IFIVE=1
      IF ( NPTS.LE. 0 ) GO TO 333
      DO 329 J=1,NPTS
      VP=V1P+FLOAT(J-1)*CVP
260  370  PRINT 900, J,VP,NEWEM(J),NEWTR(J)
      JEND=NLIM-NPTS+1
      IF(JEND.LT. 0) JEND=NLIM
      DO 330 J=JEND,NLIM
      VP=V1P+FLOAT(J-1)*CVP
285  330  PRINT 900, J,VP,NEWEM(J),NEWTR(J)
      900  FORMAT(I10,F12.6,3F15.6)
      333  CONTINUE
      GO TO (545,550),JOG
210  545  IKKL=IKKL+1
      IF(IKKL.LE. KNL) GO TO 160
      GO TO 210
      160  JUG=2
      360  BUFFER IN(KFILE,1)(V1P,NLIM)
      IF(UNIT(KFILE).EQ. 0) STOP
215  360  BUFFER IN(KFILE,1)(TR(1),TR(NLIM))
      IF(UNIT(KFILE).EQ. 0) STOP
C
C COMPUTE THE BLACK BODY EVERY 1 WAVE 0 BEGINNING AT V1P
C
220  BEGIN=V1P
      400  BEGIN
      I=1
      270  RODIES(I)=BBODY(BEGIN)
      I=I+1

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SUBROUTINE ENDOWN		74/74	OPT=1	PTN 4.0+020	03/14/78
225	IF (T .GT. T0) STOP				016510
	BEGIN=RESIN+1.0				016520
	IF (RESIN .LE. VEP+1.0) GO TO 270				016530
	IF (I .EQ. 2) BODIES(I)=BODIES(1)				016540
	CCC PRINT *, (BODIES(I), I=1, 10)				016550
230	COMON=1.44*VIP/TAVE				016560
	IF (COMON .LE. 4.005) GO TO 200				016570
	DENOM=1.0				016580
	GO TO 200				016590
	200 DENOM=1.0-EXP(-COMON)				016600
235	290 DVBBF=VIP*1.0E-4/ABS(3.0-(COMON/DENOM))				016610
	BB=BODIES(1)				016620
	TESTER=VIP				016630
	CHANGE=VIP+DVBBF				016640
	LTEST=1				016650
240	DO 200 J=1, NLIN				016660
	TRJ=TR(J)				016670
	TR(J)=1.				016680
	IF (TRJ .LE. 0.) GO TO 200				016690
	IF (TRJ .LT. 174.0) GO TO 250				016700
245	TR(J)=EXP(MIN				016710
	GO TO 200				016720
	250 TR(J)=EXP(-TRJ)				016730
	260 CONTINUE				016740
	370 FCRAT(1X1P10E11.3)				016750
250	GO TO (240, 350, 535), JUG				016760
	350 II=1				016770
170	IF (TESTER .LT. CHANGE) GO TO 190				016780
	COMON=CHANGE-POB				016790
	BB=BODIES(LTEST)-(BODIES(LTEST)-BODIES(LTEST+1))*COMON				016800
255	CHANGE=CHANGE+DVBBF				016810
	IF (CHANGE .GE. 800+1.0) GO TO 300				016820
	GO TO 190				016830
	300 LTEST=LTEST+1				016840
	BOD=BOD+1.0				016850
260	190 CONTINUE				016860
	NVS=NVS+1				016870
	GO TO 60				016880
	210 REWIND KFILE				016890
	C				016900
265	CALL SECOND(TIME1)				016910
	TIN=TIME1-TIME				016920
	PRINT P40, TIME1, TIN				016930
	RETURN				016940
	C				016950
270	C				016960
	C				016970
	220 FORMAT('0 THE TIME AT THE START OF ENDOWN IS ', F12.3)				016980
	240 FORMAT('0 THE TIME AT THE END OF ENDOWN IS ', F12.3/F12.3,				016990
	1* SECS WERE REQUIRED FOR THIS ADDITION*)				017000
275	2				017010
	ENC				017020

LISTING OF HIRACD SUBROUTINES

03/14/78

```

1 SUBROUTINE MIRACO
C
C .....
5
C
C CALCULATES MONOCHROMATIC ABSORPTION COEFFICIENT FOR SINGLE LAYER
C
10 C
C USES MIRACC ALGORITHM FOR THE DOPPLER PROFILE
C .....
C
15 COMMON GNU(250), S(250), ALFA0(250), EPP(250), NMOL(250),
C      EFDPH(250), RECALF(250)
COMMON FF(3600)
COMMON/MAIN/ KFILE, KPANEL, PD, TEMPO
COMMON/NMF/   NMOL, XID(7), SECANT, PAVE, TAVE, NMOLID(7), WK(7),
20 C      DV, V1, V2, NLayer
COMMON /XSUB/LIMIN, ILO, IMI, VBOT, VTOP, VFT, IEDF, IPANEL, ISTOP, IDATA
COMMON /NXX/  NMF, DXF, NF, NWS, DXS, NS, NVVS, DXVS, NVS, NPMAX, NSMAX, NVSM
1AX
COMMON /SUB1/ MAXF, MAXS, MAXVS, NLINF, NLIPS, NLIPVS, NLO, NHI, DVS, OVVS
25 COMMON /XPANEL/ VIP, VZP, OVP, NLIN, NSHIFT, NPYS
COMMON/XTIME/TIME, TIMRDF, TIMCNV, TIMPHL
DIMENSION ALFCOR(7), ALFD1(7), U(7), SCOR(7)
DIMENSION VO(251)
C
30 DATA NMF / 4/, DXF / 0.02/, NF /201/, NPMAX /251/
DATA NWS /16/, DXS / 0.08/, NS /201/, NSMAX /251/
DATA NVVS/64/, DXVS/ 0.32/, NVS/201/, NVSMAX/251/
C
DATA IENTER/0/, LIMIN/250/, NSHIFT/32/, NLINF/2401/, NPYS/ 0/
35 C
DATA SUBID /10M MIRACO /
C
IF (IENTER.NE.0) GO TO 10
IENTER=1
NLIMS=(NLINF/4)+1
NLIPVS=(NLIPS/4)+1
C
NOTE (DXVS/DXF) IS 16 AND (DXVS/DXS) IS 4
NBOUNDO=(DXVS/DXF)*FLOAT(NMVVS)
MAXF=NLINF+NBOUNDO
MAXS=(MAXF/4)+1
MAXVS=(MAXS/4)+1
CALL SHAPE(XD)
CALL MOLEC(1,NMOLID,NMOL,TEMPO,TAVE,PD,PAVE,SCOR,ALFCOR,ALFD1)
10 PRINT 900
PRINT 970, SUBID
TIMPDF=TIMCNV-TIMPHL=0.
PRINT 980, (XID(I),I=1,7)
OPEN KFILE
IECF=0
55 PRINT 910, KFILE
PRINT 915, SECANT
PRINT 925, PAVE,TAVE
PRINT 930, (NMOLID(M),WK(M),M=1,NMOL)
PRINT 940, DV,V1,V2
DV=OV
DVS=(DXS/DXF)*DV
DVVS=(DXVS/DXF)*DV
BOUND=FLOAT(NBOUNDO)*DV/2.
BOUNDP=BOUND*(DXF/DXVS)/2.
65 PRINT 942, BOUNDP
ALFMAX=BOUND/FLOAT(NMF)
NLO=NBOUND+1
NHI=NLIMP+NSHIFT-1
DO 98 I=1,MAXF
FF(I)=0.
50 C
WRITE (KFILE) (XID(I),I=1,7),SECANT,PAVE,TAVE,(NMOLID(M),M=1,7),
$ (WK(I),I=1,NMOL),CV,V1,V2
BUFFER CUT(KFILE,1) (XID(1),NLayer)

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SUBROUTINE MIRAGE		74/74	OPT=1	FTN 4.0+428	03/16/78
75	C	IF (UNIT(KFILE).EQ.0) STOP "99"			000040
		VFT=V1-2.*BOUND			000060
		VBOT=V1-BOUND			000080
		VTOP=V2+BOUND			000100
80	C	XKT=0.4991*TEMP			000120
		XKT=0.6991*TAVE			000140
		XKTFAC=(1./XKT) - (1./XKT0)			000160
		CALL MLEC(2,MHOLID,MHOL,TEMP0,TAVE,P0,PAVE,SCOR,ALFCOR,ALFD1)			000180
85	80	DO 90 M=1,MHOL			000200
		U(M)=WK(M)*SCOR(M)*SECANT			000220
		ICNT=0			000240
		SUMALF=0.			000260
		NCHNG=0			000280
90	C				000300
	90	CONTINUE			001000
	C				001020
	100	CONTINUE			001040
	C				001060
95		CALL SECOND (TIME)			001080
		IF (IEOP.NE.0) GO TO 150			001100
		CALL ROFILE(GNU,S,ALFA0,EPP,MOL)			001120
		CALL SECOND (TIME)			001140
		TIMROF=TIMROF+TIME-TIME0			001160
100	C				001180
		IF (IEOP.NE.0) GO TO 140			001200
	C				001220
	C	MODIFY LINE DATA FOR TEMPERATURE, PRESSURE, AND COLUMN DENSITY			001240
	C				001260
105		DO 170 I=ILO,IMI			001280
		M=MOL(I)			001300
		EDEPTH(I)=S(I)*U(M)			001320
		IF (EDEPTH(I).LE.0.) GO TO 130			001340
		ICNT=ICNT+1			001360
110		ALFD=GNU(I)*ALFD1(M)			001380
		IF (ALFD.GE.0V) GO TO 110			001400
		PRINT 945, GNU(I),S(I),ALFA0(I),ALFD,DV,M			001420
		ALFD=DV			001440
		NCHNG=NCHNG+1			001460
115	110	IF (ALFD.LE.ALFA0) GO TO 120			001480
		PRINT 950, GNU(I),S(I),ALFA0(I),ALFD,ALFA0,M			001500
		ALFD=ALFA0			001520
		NCHNG=NCHNG+1			001540
	120	CONTINUE			001560
120		SUMALF=SUMALF+ALFD			001580
		RECALF(I)=1./ALFD			001600
		EDEPTH(I)=EDEPTH(I)*EXP(-EPP(I)*XKTFAC)*RECALF(I)*			001620
		S (1.-EXP(-GNU(I)/XKT))/(1.-EXP(-GNU(I)/XKT0))			001640
	130	CONTINUE			001660
125		IF (NCHNG.GT.100) GO TO 160			001680
	140	CONTINUE			001700
	C				001720
		CALL CONVEN(GNU,EDEPTH,RECALF,MOL,FF,XD)			001740
	C				001760
130		IF (IPANEL.EQ.0) GO TO 100			001780
	C				001800
	150	CALL PANELD (FF,KFILE)			001820
	C				001840
		CALL SECOND (TIME)			001860
135		KPANEL=KPANEL+1			001880
		IF (ISTOP.NE.1) GO TO 140			001900
		END FILE KFILE			001920
	160	CONTINUE			001940
		PRINT 955,TIME,TIMROF,TIMCNV,TIMPNL			001960
140		IF (ICNT.LE.0) GO TO 170			001980
		AVALF=SUMALF/FLOAT(ICNT)			002000
		PRINT 960,AVALF,ICNT,NCHNG			002020
	C				002040
	170	RETURN			002060
	C				002080
145					002100
	C				002120
	900	FORMAT (1M0)			002140
	904	FORMAT (1X,7A10)			002160
150	910	FORMAT ('0 OUTPUT FILE NO. = ' I5)			002180
					002200

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SUBROUTINE MIRACD 74/74 OPT=1 FTM 4.6+428 03/14/78

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915 FORMAT('0 SECANT = F15.5) 001600
920 FORMAT (10(1PE10.3)) 001610
925 FORMAT('0 PRESS(MB) = F12.5/ 00 TEMP(K) = F11.2) 001620
930 FORMAT(33NO COLUMN DENSITY(MOLECULES/CM**2) , 001630
155 1 / 15X,16, * = 1PE10.3) 001640
940 FORMAT('0 DV(CM-1) = F12.8/00 V1(CM-1) = F12.4/00 V2(CM-1) = 001650
1 F12.4) 001660
942 FORMAT(17MO BOUNDF (CM-1) = ,F8.4) 001670
945 FORMAT (' -----F18.4,E14.3,3F10.6,I5) 001680
160 950 FORMAT (' ++++++-----F18.4,E14.3,3F10.6,I5) 001690
955 FORMAT (1MO,10X,'TINZ',11X,'READ',4X,'CONVOLUTION',10X,'PANEL',/ 001700
1 4F15.3) 001710
960 FORMAT ('0 AVERAGE WIDTH = F18.3, 001720
C * NO. LINES = I10, * NO. CHANGES = I10 ) 001730
165 970 FORMAT(1MO,9X,A10) 001740
END 001750

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SUBROUTINE CONVEND 74/74 OPT=1 FTM 4.6+428 03/14/78

```

1 SUBROUTINE CONVEND(GNU,EFPTH,RECALF,MOL,FF,XD) 001760
COMMON,NEW/ NMOL,XID(7),SECANT,PAVE,TAVE,NMOLT(7),MK(7), 001770
C DV,V1,V2,NLAYER 001780
COMMON /XSUS/LIMN,ILO,IMI,VROT,VTOI,VFT,IEOF,IPANEL,ISTOP,ICATA 001790
5 COMMON /NXX/ NMF,DXF,NF,NMS,DXS,NS,NMVS,DXVS,NVS,NFMAX,NSMAX,NVSM 001800
1AX 001810
COMMON /SUB1/ MAXF,MAXS,MAXVS,NLIMP,NLIPV,NLIPVS,NLC,NPI,DVS,CVVS 001820
COMMON/XTIME/TIME,TIMRDF,TIMCHV,TIMPMI 001830
10 DIMENSION GNU(1), EFPTH(1), RECALF(1), FF(1) 001840
DIMENSION MOL(1) 001850
DIMENSION XO(1) 001860
CALL SFCOND (TIME) 001870
PATVX=CVVS/DXVS 001880
FVS=FLOAT(NMVS)/DXVS 001890
CONF=CVVS/DV-1. 001900
13 IF (ILO.GT.IMI) GO TO 50 001910
DO 40 I=ILO,IMI 001920
DEPTH=EFPTH(I) 001930
IF(DEPTH.LE.0.) GO TO 40 001940
ZSLOPE=RECALF(I)*PATVX 001950
ZINT=(GNU(I)-VFT)/DVS 001960
BFVS=FVS/ZSLOPE 001970
JMAX=(ZINT+BFVS)+2. 001980
IF (JMAX.LE.MAXVS) GO TO 20 001990
25 ILAST=I-1 002000
GO TO 50 002010
20 JMIN=(ZINT-BFVS)+2. 002020
JMINF=(ZINT*CONF) 002030
ZVS=(PLCAT(JMIN-2)-ZINT)*ZSLOPE 002040
30 ZF=ZVS+(FLOAT(JMINF)-ZINT*CONF)*ZSLOPE 002050
DO 30 JJ=JMIN,JMAX 002060
JF=JMINF+JJ 002070
ZF=ZF+ZSLOPE 002080
35 IZF=ABS(ZF)+1.5 002090
FF(JF)=FF(JF)+DEPTH*XO(IZF) 002100
30 CONTINUE 002110
40 CONTINUE 002120
ILAST=IMI 002130
C IDATA=0 FOR MORE DATA REQUIRED ** IDATA=1 IF NO MORE DATA REQUIRED 002140
40 IPANEL=IDATA 002150
GO TO 60 002160
50 CONTINUE 002170
IPANEL=1 002180
60 ILO=ILAST+1 002190
CALL SFCOND (TIME) 002200
TIMCHV=TIMCHV+TIME-TIME0 002210
45 RETURN 002220
C 002230
FME 002240

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SUBROUTINE PANELD

74/74 OPT=1

PTN 4.6+428

03/14/78

1		SUBROUTINE PANELD (FF,KFILE)	002250
		COMMON/NEW/ NMOL,XIN(7),SECANT,PAVE,TAVE,MNOLID(7),MK(7),	002260
	C	OV,V1,V2,NLAYER	002270
		COMMON /XSUB/LININ,ILC,IMI,VBOT,VTOP,VFT,IEOF,IPANEL,ISTOP,ICATA	002280
5		COMMON /SUB1/ MAXF,MAXS,MAXVS,NLINF,NLIMS,NLIVS,NLO,NMI,DVS,DVVS	002290
		COMMON /XPANFL/ VIP,VPP,OVP,NLIN,NSHIFT,NPTS	002300
		COMMON/XTIME/TIME,TIMROP,TIMCNV,TIMPHL	002310
		DIMENSION FF(1)	002320
		CALL SECOND (TIME)	002330
10		ISTOP=0	002340
		NMI=(V2-VFT)/OV+1.5	002350
		IF (NMI.GE.NMI) ISTOP=1	002360
		IF (ISTOP.EQ.1) NMI=NMI	002370
		JMXPR=NLO+NPTS	002380
15		JJPR=NMI-NPTS	002390
		LINLO=(NLO-1)/4-3	002400
		LINMI=(NMI/4)+1	002410
		IF (NPTS.EQ.0) GO TO 80	002420
		DO 40 J=NLO,JMXPR	002430
20		VP=VFT+FLOAT(J-1)*OV	002440
	40	P=INT 900, J,FF(J),VP	002450
		DO 50 J=JJPR,NMI	002460
		VP=VFT+FLOAT(J-1)*OV	002470
	50	PRINT 900, J,FF(J),VP	002480
25	60	CONTINUE	002490
		NLIN=NMI-NLO+1	002500
		VIP=VFT+FLOAT(NLO-1)*OV	002510
		V2P=VFT+FLOAT(NMI-1)*OV	002520
	C	V1P IS FIRST FRFQ OF PANELV	002530
30	C	V2P IS LAST FRFQ OF PANELV	002540
	S	WRITE (KFILE) VIP,V2P,OVP,NLIN	002550
	S	WRITE (KFILE) (FF(J),J=NLO,NMI)	002560
		BUFFER OUT (KFILE,1) (VIP,NLIN)	002570
		IF (UNIT(KFILE).EQ.0) STOP	002580
35		BUFFER OUT (KFILE,1) (FF(NLO),FF(NMI))	002590
		IF (UNIT(KFILE).EQ.0) STOP	002600
		VFT=VFT+FLOAT(NLINP-1)*OV	002610
		IF (ISTOP.EQ.1) GO TO 140	002620
		JF=1	002630
40		DO 80 J=NLINP,MAXF	002640
		FF(JF)=FF(J)	002650
	80	JF=JF+1	002660
		DO 90 J=JF,MAXF	002670
	90	FF(J)=F.	002680
45		NLC=NSHIFT+1	002690
	140	CALL SECOND (TIME)	002700
		TIMPHL=TIMPHL+TIME-TIME0	002710
		RETURN	002720
	C		002730
50	C		002740
	C		002750
	900	FORMAT (I10,24X,E12.5,F12.5)	002760
		END	002770

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74/74 OPT=1

FYH 4.64428

03/16/78

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1      SUBROUTINE MIRACL
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SUBROUTINE MIRACL	74/74	OPT=1	FTN 4.6-428	03/14/78
75	C	WRITE (KFILE) (XID(I),I=1,7),SECANT,PAVE,TAVE,(NMOLID(M),M=1,7),	000840	
	S	1 (MK(I),I=1,NMOL),DV,V1,V2	000850	
	S	2 BUFFER OUT(KFILE,1) (XID(1),MLAYER)	000860	
		IF (UNIT(KFILE).EQ.8) STOP "99"	000870	
80	C	VFT=V1-2.*BOUND	000880	
		VROT=V1-BOUND	000890	
		VTC=V2+BOUND	000900	
85	C	XKTO=8.6951*TEMP8	000910	
		KKT =8.6951*TAVE	000920	
		XKTFAC=(1./XKT) - (1./XKTO)	000930	
		CALL MOLF(2,NMOLID,NMOL,TEMP8,TAVE,P8,PAVE,SCOR,ALFCOR,ALFD1)	000940	
		DO 88 M=1,NMOL	000950	
90	80	U(M)=MK(M)*SCOR(M)*SECANT	000960	
		ICNT=9	000970	
		SUMALF=8.	000980	
		NCHNG=0	000990	
95	C	CONTINUE	001000	
	90	CONTINUE	001010	
	C	CONTINUE	001020	
	100	CONTINUE	001030	
	C	CALL SECOND (TIME8)	001040	
100		IF (IEOF.NE.0) GO TO 130	001050	
		CALL RDPFILE(GNU,S,ALFAD,EPP,MOL)	001060	
		CALL SECOND (TIME)	001070	
		TIMRDF=TIMRDF+TIME-TIME8	001080	
105	C	IF (IEOF.NE.0) GO TO 140	001090	
	C	MODIFY LINE DATA FOR TEMPERATURE,PRESSURE, AND COLUMN DENSITY	001100	
	C	DO 130 I=ILO,IMI	001110	
		M=MOL(I)	001120	
110		EFDPH(I)=S(I)*U(M)	001130	
		IF (EFDPH(I).LE.0.) GO TO 170	001140	
		ICHT=ICNT+1	001150	
		ALFL=ALFAD(I)*ALFCOR(P)	001160	
115		IF (ALFL.GE.DV) GO TO 110	001170	
		PRINT 945, GNU(I),S(I),ALFAD(I),ALFL,DV,M	001180	
		ALFL=DV	001190	
		NCHNG=NCHNG+1	001200	
120	110	IF (ALFL.LF.ALFLMAX) GO TO 120	001210	
		PRINT 950, GNU(I),S(I),ALFAD(I),ALFL,ALFLMAX,M	001220	
		ALFL=ALFLMAX	001230	
		NCHNG=NCHNG+1	001240	
125	120	CONTINUE	001250	
		SUMALF=SUMALF+ALFL	001260	
		RECALF(I)=1./ALFL	001270	
		FFDPH(I)=FFDPH(I)*EXP(-(XKT(I)*XKTFAC)*RECALF(I)*	001280	
		(1.-EXP(-GNU(I)/XKT))/(1.-EXP(-GNU(I)/XKTO))	001290	
130	130	CONTINUE	001300	
		IF (NCHNG.GT.100) GO TO 160	001310	
135	140	CONTINUE	001320	
	C	CALL CONVMF (GNU,EFDPH,RECALF,MOL,FF,SP,VSP,	001330	
		X,XS,XVS)	001340	
140	C	IF (TPANEL.EQ.0) GO TO 100	001350	
	C	CALL PANEL (FF,SP,VSP,KFILE)	001360	
	150	CALL SECOND (TIME)	001370	
		KPANEL=KPANEL+1	001380	
		IF (ISTOP.NE.1) GO TO 140	001390	
		END FILE KFILE	001400	
	160	CONTINUE	001410	
145		PRINT 955,TIME,TIMRDF,TIMCHV,TIMPNL	001420	
		IF (ICNT.LE.0) GO TO 170	001430	
		AVALF=SUMALF/FLOAT(ICNT)	001440	
		PRINT 960,AVALF,ICNT,NCHNG	001450	

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SUBROUTINE MIRACL 74/74 OPT=1

FTN 4.6+428

03/14/78

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C
170 RETURN
C
C
900 FORMAT (1H0)
904 FORMAT(1X,7A10)
155 910 FORMAT(08 OUTPUT FILE NO. = F15.5)
915 FORMAT(08 SECANT = F15.5)
920 FORMAT (10(1PE10.3))
925 FORMAT(08 PRESS(MB) = F12.5/ 08 TEMP(K) = F11.2)
930 FORMAT(33H0 COLUMN DENSITY(MOLECULES/CM**2) ,
160 1 / (1X,45, * = * 1PE10.3) )
940 FORMAT(08 P(CM-1) = F12.8/08 V1(CM-1) = F12.4/08 V2(CM-1) =
1 F12.4)
945 FORMAT(17H0 BOUNDS(CM-1) = ,F8.4)
945 FORMAT (0 -----F10.4,E14.3,3F10.6,15)
165 950 FORMAT (0 *****F10.4,E14.3,3F10.6,15)
955 FORMAT (1H0,10X,*TIME*,11X,*RAD*,4X,*CONVOLUTION*,10X,*PANEL*/
1 4F15.3)
960 FORMAT(08 AVERAGE WIDTH = F10.6,
C 08 NO. LINES = I10, 08 NO. CHANGES = I10 )
170 970 FORMAT(1H0,9X,A10)
END

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SUBROUTINE CONVFNL 74/74 OPT=1

FTN 4.6+428

03/14/78

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1 SUBROUTINE CONVFNL(GNC,EPDPTH,RECALF,MOL,FF,SF,VSF,XF,XS,XVS)
COMMON/NEW/ NMOL,XID(7),SECANT,PAVE,TAVE,MOLID(7),WK(7),
C DV,V1,XF,NLAYER
COMMON /XSUB/LIMN,ILO,INT,VROT,VTOP,VFT,IEOF,I/PANEL,I/STOP,I/DATE
5 COMMON /XXX/ NMF,DXF,NF,NMS,DXS,NS,NMVS,DXVS,AVS,NPMAX,NSMAX,AVSM
14X
COMMON /SUB1/ MAXF,MAXS,MAXVS,NLINF,NLINS,NLIPVS,NLO,NMI,DVS,DVVS
COMMON/XTIME/TIME,TIMPOF,TIMCNV,TIMCNL
10 DIMENSION GNU(1), EPDPTH(1), RECALF(1), FF(1), SF(1), VSF(1)
DIMENSION MOL(1)
DIMENSION XF(1), XS(1), XVS(1)
CALL SECOND (TIME0)
DATTX=DVVS/DVVS
FVS=FLOAT(NMVS)/DXVS
15 CONF=DVVS/DV-1.
CONS=CVVS/DVS-1.
IF (ILO.GT.INT) GO TO 50
DO 40 I=ILO,INT
DEPTMI=EPDPTH(I)
20 IF(DEPTMI.LE.0.) GO TO 40
ZL(PE=RECALF(I)*DATTX
ZINT=(GNU(I)-VFT)/DVVS
BFVS=FVS/ZSLOPE
JMAX=(ZINT*BFVS)+2.
25 IF (JMAX.LE.MAXVS) GO TO 20
ILAST=I-1
GO TO 50
20 JMIN=(ZINT-BFVS)+2.
JINF=(ZINT*CONF)
JMIN=(ZINT*CONS)
35 ZVS=(FLOAT(JMIN-2)-ZINT)*ZSLOPE
ZS=ZVS+(FLOAT(JMIN)-ZINT*CONS)*ZSLOPE
ZF=ZVS+(FLOAT(JINF)-ZINT*CONF)*ZSLOPE
DO 30 JJ=JMIN,JMAX
35 JS=JMIN+JJ
JF=JINF+JJ
ZVS=ZVS+ZSLOPE
ZS=ZS+ZSLOPE
ZF=ZF+ZSLOPE
40 ZV%=(ZVS+ZVS)*1.5
ZS%=(ZS+ZS)*1.5
ZF%=(ZF+ZF)*1.5
VRF(JJ)=VSF(JJ)+DEPTMI*XVS(IZVS)
SF(JS)=SF(JS)+DEPTMI*VS(IJS)
45 FF(JF)=FF(JF)+DEPTMI*XF(IJF)

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SUBROUTINE CONVPNL		76/76	OPT=1	FTN 4.6+628	03/14/78
	30	CONTINUE			002260
	40	CONTINUE			002270
		ILAST=INT			002280
	C	IOATA=1 FOR MORE DATA REQUIRED ** IOATA=1 IF NO MORE DATA REQUIRED			002290
50		IPANEL=IOATA			002300
		GO TO 60			002310
	50	CONTINUE			002320
		IPANEL=1			002330
	60	ILO=ILAST+1			002340
55		CALL SECOND (TIME)			002350
		TIMECV=TIMECV+TIME-TIME0			002360
		RETURN			002370
	C				002380
		END			002390